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WATER SUPPLY AND WATER QUALITY CONTROL STUDY. MERAMEC RIVER BASIN, MISSOURI

Public Health Service
Kansas City, Missouri

December 1964

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WATER SUPPLY AND WATER QUALITY CONTROL STUDY

MERAMEC RIVER BASIN MISSOURI

Study of Needs and Value of Storage for Municipal and Industrial Water Supply and Water Quality Control

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U.S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
PUBLIC HEALTH SERVICE REGION VI
KANSAS CITY, MISSOURI

WATER SUPPLY AND
WATER QUALITY CONTROL STUDY
MERAMEC RIVER BASIN
MISSOURI

Prepared for

DEPARTMENT OF THE ARMY

U. S. Army Engineer District

St. Louis, Missouri

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VI
Kansas City, Missouri

DECEMBER 1964

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I. INTRODUCTION

Authority

In a letter dated May 8, 1961, the District Engineer, U. S. Army Engineer District, St. Louis, Missouri, requested the U. S. Public Health Service, Region VI, Kansas City, Missouri, to determine the need for and value of municipal and industrial water supply and storage for water quality control in the Meramec River Basin.

This study has been made in accordance with the Memorandum of Agreement between the Department of the Army and the Department of Health, Education and Welfare dated November 1958, relating to the Water Supply Act of 1958, Public Law 85-500 and the Federal Water Pollution Control Act, Public Law 84-660, both as amended by P. L. 87-88, July 1961.

Purpose and Scope

This study is a preliminary determination of the present and future need for municipal and industrial water supply and the economic value of such supply and the need for and value of storage for flow regulation for water quality control in the Meramec River Basin which has a drainage area of 3,954 square miles. The 100 year study period, 1970 to 2070, was requested by the Corps of Engineers.

Acknowledgments

This study was made possible through the cooperation and assist-

ance of the following Federal, State and local agencies:

1. U. S. Army Engineer District, St. Louis, Corps of Engineers
2. U. S. Bureau of Mines, Region IV, Oklahoma
3. U. S. Forest Service, North Central Region, Wisconsin
4. Area Redevelopment Administration, Missouri
5. National Park Service, Region 2, Nebraska
6. Missouri Water Pollution Board, Missouri
7. Missouri Division of Health, Missouri
8. State of Missouri, Division of Geological Survey and Water Resources, Missouri
9. Missouri Conservation Commission, Missouri
10. Missouri Water Resources Board, Missouri
11. St. Louis County Health Department, Missouri
12. Jefferson County Health Department, Missouri
13. St. Louis County Planning Commission, Missouri
14. Metropolitan St. Louis Sewer District, Missouri
15. Community Development, University of Missouri Extension, Missouri
16. Meramec Basin Corporation, Missouri
17. St. Louis County Water Company, Missouri
18. Layne-Western, Missouri
19. E. B. A. S. Co Consulting Firm
20. Representatives of the Municipalities in the Basin

II. SUMMARY AND CONCLUSIONS

Summary

1. Thirty-one reservoirs are proposed for construction in the Meramec River Basin by the Corps of Engineers. Seven are major impoundments, and the remaining are classified as intermediate and/or headwater reservoirs.

2. The location and boundaries of the study area coincide with those of the basin. The study area was divided into two sub-areas which are referred to as the upper and lower areas. See Map of Study Area, Figure VIII-2 at the back of the report.

3. The future water needs were based on an analysis of the potential economic development of the basin. The economy of the basin is diversified with manufacturing, agriculture, mining and related services in the upper part of the basin and the complex St. Louis Standard Metropolitan Statistical Area (SMSA) in the lower portion of the basin.

4. The need for storage in the years 1970, 2020, and 2070 for municipal and industrial water supplies and quality control regulation was determined.

Conclusions

1. The population of the Meramec Basin in the St. Louis SMSA is expected to increase from approximately 92 thousand in 1960 to about two million in 2070. An increase in population from about 120

thousand in 1960 to about one million by 2070 is estimated for the upper area.

2. A 300 ton per day pulp mill which is expected to begin operations by 1970 in the upper area will be the largest single water user in the basin.

3. The ground water resources in the upper area are sufficient to meet present and projected municipal and industrial requirements of 32 million gallons per day (mgd) by 1970, 54 mgd by 2020, and 138 mgd by 2070.

4. No municipal and industrial water supply benefits are expected to accrue to the project in the upper area.

5. In the lower area, municipal and industrial demands are expected to reach 17 mgd by 1970, 93 mgd by 2020, and 400 mgd by 2070. By utilizing all of the available ground water resources in this area, a demand of 25 mgd can be supplied.

6. In the lower area, facilities to supply as much as 345 mgd from storage or a pipeline from the Missouri will be needed to supplement available well supplies and natural low flows expected once in 50 years. The year of first need will be 2025, based on minimum summer flows and maximum seasonal needs. Based on the most likely alternative (a single purpose project), water supply storage in Federal multipurpose impoundments to meet these needs is estimated to have an annual value of $107,000 for the 100-year period.

7. Maintenance of satisfactory water quality in the Meramec River basin will benefit a wide spectrum of water uses in the study

area. By 2070, three million people will live in the area which will benefit through streamflow regulation by the improvement of water quality in approximately 450 river miles of stream in the basin. Municipal and industrial raw water supplies of satisfacotry quality will be available. Water treatment cost will not be increased. Municipal growth will not be jeopardized by a shortage of water. Recreational opportunities, including fishing, swimming, water skiing, and boating will be increased. There is only limited skiing in the basin but there is considerable fishing, swimming and boating. According to the Fish and Wildlife Service present fisherman-use along project affected reaches exceed 230,000 angler days annually. Corps of Engineer projected fishing demands by reservoir and stream fishermen are approximately 3,400,000 fisherman-days in 1970, 4,700,000 fisherman-days in 2020, and slightly less than 6,700,000 fisherman-days by the year 2070. Demands which can be met by the 31 proposed reservoirs, angler-use sites, and improved channel flow are estimated at approximately 2,000,000 fisherman-days by 1970, 2,300,000 fisherman-days by 2020, and 2,700,000 fisherman-days by the year 2070. The esthetic values of the streams stemming from clean surface waters, a satisfactory public health water environment, and preservation of property values in areas contiguous to the stream will thereby be assured. These benefits may be credited to storage in water quality control only if assurance is given that adequate treatment will be provided. Practically all communities now have adequate waste treatment plants either

in operation or under construction. The benefits are considered widespread and general in nature.

8. The greatest demand for quality control water will be in the lower area. A capacity to provide for a draft on storage of 900,000 acre feet (considering carry over) will be needed by 2070 to assure maintenance of water quality objectives in 95% of the years. The average annual value of storage for quality control in the lower area, based on the most likely alternative, is $595,500 per year for the 100-year period. The most likely alternative is a combination of pumping of treated wastes to the Mississippi River, and an annual draft on storage* of 215,000 acre feet for regulation of flow to accommodate wastes in rural and urban runoff.

9. An annual draft on storage of 56,200 acre feet will be needed in the upper area for water quality control by 2070. The three reservoirs required have an average annual value of $469,300 per year, based on the most likely alternative single purpose reservoirs.

*Annual draft-on-storage is the sum of the incremental excesses of needed releases over inflows during a climatic year.

III. PROJECT DESCRIPTION

Location

The main stem of the Meramec River rises in the northern part of the St. Francois mountains on the Ozark plateau and flows in a northeasterly direction for about 200 miles, emptying into the Mississippi River 20 miles below the city of St. Louis. The river system is south of the Missouri River Basin and drains 3,952 square miles in eastern Missouri. See Map of area, Figure VIII-2 at the back of the report.

History

The first studies of the Meramec River Basin were made about 1880 and since that time many studies and reports have been made by various Federal, State, and local agencies.

Pursuant to the River and Harbor Act of January 21, 1927, the Army Corps of Engineers made a series of flood control, navigation, water power, and irrigation studies known as the "308" reports. A report on the Meramec River, published in 1930 as House Document No. 686, recommended against improvements in the Meramec Basin because of lack of economic justification. Subsequently, a detailed plan for three reservoirs was presented to the public in 1949. This plan was deferred with recommendations for further study.

In June of 1958, the local Chambers of Commerce organized the Meramec Basin Corporation. Under the auspices of the corporation, the Meramec Basin Research Project was financed to secure an unbiased,

comprehensive study of the Meramec's water resources. The study was completed in December, 1961, and the final report entitled "The Meramec Basin - Water and Economic Development" was published in February 1962.

In April 1960, Congressional authorization was obtained for a new comprehensive study of the basin. The Army Corps of Engineers, St. Louis District, was requested to review all previous reports on the Meramec River Basin and determine whether the proposed projects for the basin should be modified to insure maximum benefits in the interest of flood control, water conservation, navigation and other purposes.

Present Study

The study area includes all or parts of 11 counties which are drained by the Meramec River and its tributaries. The two principal tributaries are the Bourbeuse River (828 square miles drainage; 128 miles in length) and the Big River (1,021 square miles drainage; 130 miles in length). Minor branches are Huzzah, Courtois, Indian, Dry Fork, and Brazil Creeks. The maximum width of the entire watershed is approximately 80 miles and the maximum length is about 105 miles.

Currently, 31 reservoir sites are being investigated from an engineering and economic standpoint. Major impoundments are proposed for seven of the sites and intermediate and headwater reservoirs are

proposed for the remaining sites. Table No. III-1 gives the names and capacities of the seven major impoundments and Exhibit No. 1 in the Appendix depicts similar data for the 24 intermediate and headwater reservoirs.

Table No. III-1

* Reservoir Data 9/

Meramec River Basin

	Flood Control Pool Storage (Acre-Feet)	100-Year Sediment Storage (Acre-Feet)	Joint-use Pool (Acre-Feet)	Total Storage (Acre-Feet)
No. 2A Pineford	196,700	12,000	76,300	285,000
No. 5 Washington Park	---	5,600	141,600	147,200
No. 9 Irondale	23,900	5,800	131,300	161,000
No. 40 Virginia Mines	---	9,000	101,300	110,300
No. 17 Meramec Park	581,600	18,200	400,000	1,000,000
No. 27 Salem	30,000	6,000	125,200	161,200
No. 29 Union	355,600	11,900	160,500	528,000

* Revised figures furnished by the Corps of Engineers, St. Louis, Mo.

IV. DESCRIPTION OF THE STUDY AREA

Location and Boundaries

The study area is the Meramec River Basin bounded by the Missouri River Basin to the north, the Gasconade to the west, the Mississippi River to the east and the Current, Black, and St. Francis River Basins to the south. The study area has been divided into upper and lower subareas because of differences in economy, growth rate, and water resources within the basin. The boundaries of the two subareas are shown in the Map, Figure VIII-2. Included are 11 counties shown in Table No. IV-1 and on Figure VIII-3.

Table No. IV-1

Study Area - Counties

Meramec River Basin

Crawford	Maries
Dent	Phelps
Franklin	St. Francois
Gasconade	St. Louis
Iron	Washington
Jefferson	

Geography [10/]

The northern part of the Meramec River Basin is gently rolling and predominantly agricultural. The land surface becomes progressively rougher and more wooded to the south. Elevation above sea level ranges

from 400 feet in the northeast to 1,400 feet in the southwest. The streams in the southern part of the basin are swift and clear and generally have narrow valleys. To the north the Bourbeuse River and its tributaries are slower and turbid.

Climate

Throughout the basin the climate is generally uniform. The average annual temperature is approximately 56° F. with a range from 0° F. to 90° F. The average frost-free growing season has a duration of about 210 days. The average annual rainfall increases from 37 inches in the northeast to 42 inches in the southwest.

Principal Communities

The principal municipalities in the study area and the streams receiving wastes from the municipalities are shown below. The lower area includes many unincorporated suburbs which are part of the heavily populated St. Louis SMSA.

Upper Area

Municipality	1960 Population	Receiving Stream		
Bonne Terre	3,219			Big River
Potosi	2,805	Branch of Mine Breton Creek,	Mineral Fork,	Big River
River Mines	12,000			Big River
Rolla	11,132	Love Creek,	Dry Fork,	Meramec
		Burgher Branch of Little Dry Fork,	Dry Fork,	Meramec

(cont'd)

Upper Area

Municipality	1960 Population	Receiving Stream	
St. Clair	2,711		
Salem	3,870	Spring Creek	Bourbeuse
Sullivan	4,098		Meramec
Union	3,937		Meramec-Bourbeuse
			Bourbeuse

Lower Area

Valley Park	3,452		
Kirkwood	29,241	Sugar Creek	Meramec
Pacific	2,795		Meramec
			Meramec

V. THE ECONOMY

Present

The Meramec River Basin has a diversified economy. The northeastern portion of the basin, which includes parts of St. Louis and Jefferson Counties (see Map of Area, Figure VIII-2), is a part of the heavily populated St. Louis Standard Metropolitan Statistical Area (SMSA). The remainder of the basin is less heavily populated and the economy is based on services, manufacturing, agriculture, and mining, in that order of importance. Refer to Table No. V-1.

Table No. V-1

The Number and Percentage of the Labor Force 1/ by Major Classifications in the Upper Meramec River Basin Counties

	1940		1950		1960	
	Number (Thousands)	Percent	Number (Thousands)	Percent	Number (Thousands)	Percent
Farm	16.8	29	14.1	25	7.1	12
Mining	3.8	7	3.9	7	3.1	5
Manufacturing	7.6	13	11.9	21	15.3	26
Total Basic	28.2	49	29.9	53	25.5	43
Total Service	24.7	43	24.2	43	31.6	52
Unemployed	4.1	8	2.0	4	3.2	5
Total Labor Force	57.0	100	56.1	100	60.3	100

Approximately 60 percent or 1.5 million acres of the basin is forested, amounting to about 7 million cords of growing stock.

Sixty percent is in poletimber; the remaining 40 percent is in sawtimber (refer to Table No. V-2). Poletimber is used primarily for fuelwood, posts and construction. Sawtimber is used for hardwood flooring, lumber, veneer, and cooperage. Employment related to timber resources is estimated at approximately 600, or about one percent of the total labor force in the upper area.

Table No. V-2

Timber Resources Available 2/

Meramec River Basin

	1959		
	Poletimber (Thousand Cords)	Sawtimber (Million Board Feet)	Total (Thousand Cords)
Softwoods	320	152	625
Hard Hardwoods	3,660	1,150	5,960
Soft Hardwoods	115	75	265
Total	4,095	1,377	6,850
Percent	60	40	100

	2060		
	Poletimber (Thousand Cords)	Sawtimber (Million Board Feet)	Total (Thousand Cords)
Softwoods	800	430	1,660
Hard Hardwoods	6,330	1,950	10,230
Soft Hardwoods	380	175	630
Total	7,510	2,555	12,520
Percent	60	40	100

Iron, lead, zinc, barite, clay, limestone, sand and gravel of commercial value are available in the Basin. In 1960, over 3,000 persons were employed in mining with approximately 2,300 in lead and iron ore extraction in St. Francois County. During the past ten years, the dollar value of mineral production ranged from the low of approximately $44.4 million in 1958 to the high of approximately $60.8 million in 1956 (adjusted to the 1954 value of the dollar). Reduction in lead mining activities was largely responsible for this decrease. Over 50 percent of this value was earned in St. Francois County (refer to Table No. V-3). [3,4/]

Table No. V-3

Values of Minerals Extracted [4/]

Meramec River Basin

Millions of Dollars*

	1954	1955	1956	1957	1958	1959	1960
St. Francois County	34.4	39.8	38.6	33.7	24.9	23.5	23.8
Remainder of Basin	16.6	18.0	22.2	19.8	19.5	21.7	21.4
Total	51.0	57.8	60.8	53.5	44.4	45.2	45.2

*Adjusted to the 1954 value of the dollar.

Employment in manufacturing has more than doubled in the past 20 years, (refer to Table No. V-1), and is a major factor in the economy of the Basin, employing an estimated 15,000 persons, approx-

imately 26 percent of the total labor force in 1960. Forty-seven percent of the manufacturing employment was in nondurables, principally leather and leather products.[1/]

Agriculture consists primarily of the production of livestock and livestock products. In 1960, livestock and its products accounted for three-fourths of the $45.6 million total agricultural sales (see Table No. V-4). Agricultural employment has been decreasing, from 16,743 in 1940 to approximately 7,000 in 1960.[5/]

Table No. V-4

Agricultural Data [5/]

Meramec River Basin

1950 - 1959

	Number Farms	Cropland Harvested (Acres)	Value of Livestock & Livestock Products* (Millions of Dollars)	Value of All Crops Sold* (Millions of Dollars)
1950	18,246	565,499	27.3	36.1
1954	16,363	521,167	24.4	32.9
1959	12,771	466,756	34.2	45.6

*Adjusted to the 1954 value of the dollar.

The total Meramec Basin population has increased from approximately 121,000 in 1910 to about 212,000 in 1960. The major growth occurred in St. Louis and Jefferson Counties, where the increase was from approximately 16,000 in 1910 to an estimated 92,000 in

1960. During this period the Basin's urban population increased from about 4,000 persons to approximately 45,000. The rural population increased from approximately 116,000 to about 167,000. (Refer to Table No. V-5). 6/

Table No. V-5

Population Data 6/

Meramec River Basin

	1910	1920	1930	1940	1950	1960
Rural	116,630	105,476	96,221	104,873	110,342	167,486
Urban	4,613	9,264	12,177	16,879	30,171	44,321
Total	121,243	114,740	108,398	121,752	140,513	211,807

Future

The proximity of the basin to the St. Louis SMSA will have the most significant effect on its future growth. Expansion of the St. Louis SMSA will be felt throughout the basin in home building, industrial site development, the provision of food, minerals, forest materials and products for the increased market.

The expected regional and national increases in demands for forestry products will be met in part by the Meramec Basin. The U. S. Forest Service expects an increase in the Basin in sawtimber production from the present cutting of 27 million board feet annually to a projected 80 million board feet annually by 2060. A 300 ton pulp mill,

employing 100 persons, is expected to locate in the basin and begin operations by 1970. Total employment in the lumber and timber operations is expected to increase to about 1,200 persons by 2070.[2/]

Lead production is expected to increase from approximately 100,000 tons in 1960 to about 220,000 tons in 2000. The reserves are then expected to begin phasing out and may be exhausted by 2020. However, there are deposits of lead in the White River Basin directly to the south which should continue to support an employment of about 3,000 from 2020 to 2070.[3/]

Barite production is expected to increase from about 180,000 tons in 1960 to about 270,000 by 2000. The barite reserves should then phase out and be exhausted by 2020. Employment is expected to reach a peak of approximately 500 by 2000.[3/]

Iron ore extraction is expected to increase at a rate of one percent per year compounded, and reach about 10 million tons annually by 2070 from its 1960 production of 232,000 tons. Employment in this category is expected to reach a peak of about 3,000 by 2070.[3/]

Limestone, clay, sand and gravel production are also expected to increase, with employment gradually increasing from approximately 500 in 1960 to about 1,000 by 2070. Table No. V-6 shows production and employment projections in the mining category.[3/]

Table No. V-6

Production and Employment Projections in Mineral Extractions[3/]

Meramec River Basin

1960 - 2000 - 2070

	1960		2000		2070	
	Production (Tons)	Employment	Production (Tons)	Employment	Production (Tons)	Employment
Lead	103,904	*	220,000	3,000	-	3,000
Barite	180,702	*	270,000	500	-	-
Iron	232,619	*	2,150,000	700	10,000,000	3,000
Sand & Gravel	1,500,000	*	3,500,000		5,200,000	

*Data Unavailable

Manufacturing employment in the basin counties, excluding St. Louis and Jefferson Counties, is expected to increase from approximately 15,000 in 1960 to 48,000 in 2020 and over 100,000 in 2070. The major increases will be in the categories of leather and leather products, fabricated metals, machinery, vehicles, textile and apparel, and food and kindred products. (Refer to Table No. V-7)

Agricultural production in the basin is expected to increase. Farm output is expected to increase about 300 percent by 2070, with the major portion of this production being utilized in the St. Louis SMSA. In response to a continual increase in technology, agricultural employment is expected to decrease from about 6,900 in 1960 to 5,500 in 2070.

Table No. V-7

Projected Employment of Labor Force

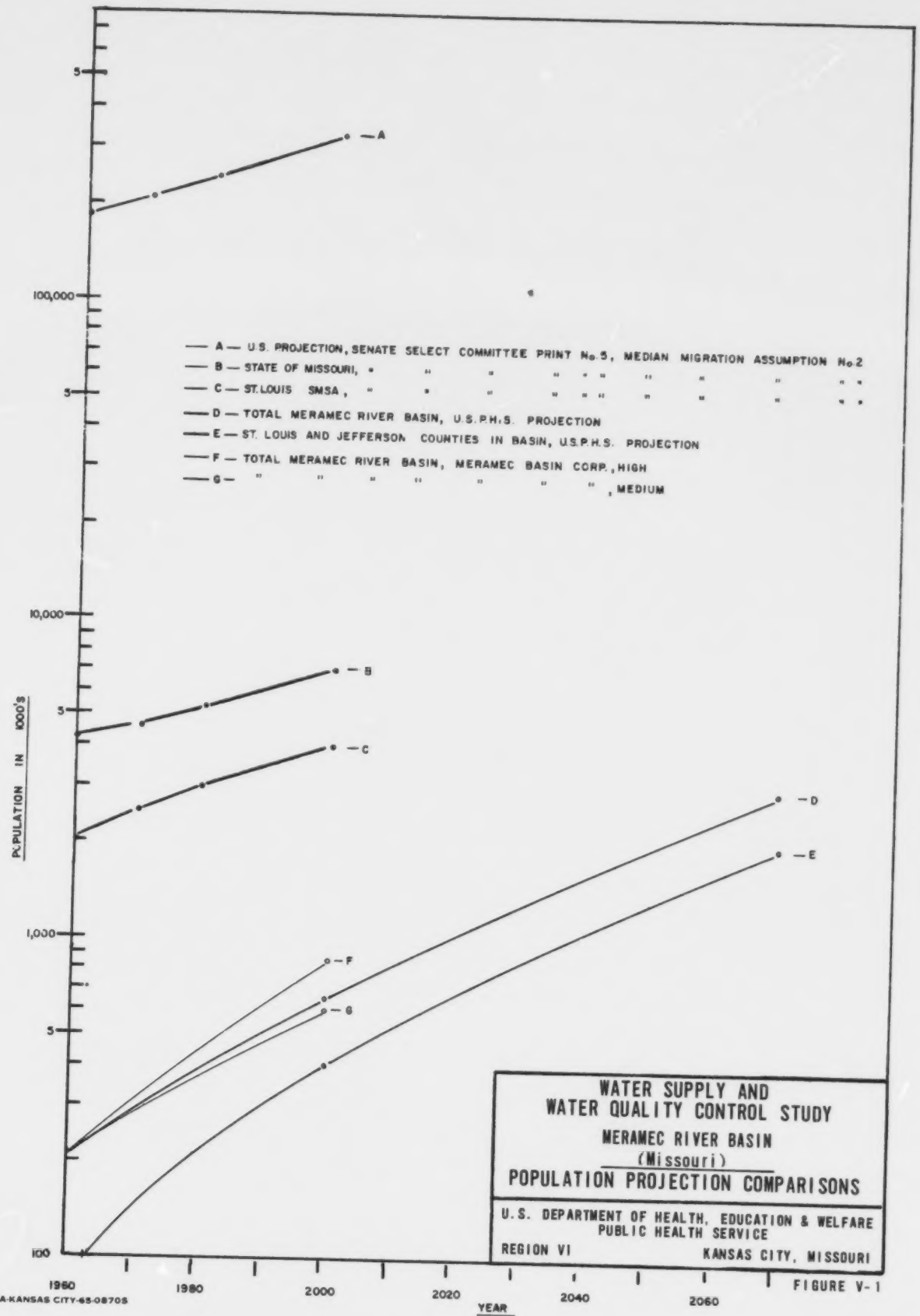
Upper Meramec River Basin Counties

2020 - 2070

	2020		2070	
	Number (Thousands)	Percent of Labor Force	Number (Thousands)	Percent of Labor Force
Farm, Forestry & Fisheries	6.0	4	5.5	1
Mining	6.0	4	7.5	2
Manufacturing	48.0	30	102.0	29
Furniture, Lumber & Wood Products	-	(1)	-	(1)
Fabricating, Metal, Mach., Veh. & Other Durables	-	(8)	-	(10)
Food & Kindred	-	(2)	-	(3)
Textile & Apparel	-	(3)	-	(3)
Other Nondurables	-	(11)	-	(10)
Miscellaneous	-	(5)	-	(1)
Total Basic	60.0	38	115.0	32
Total Service	95.0	59	225.0	65
Unemployment	5.0	3	10.0	3
Total Labor Force	160.0	100	350.0	100

Population in the Meramec Basin, particularly that portion which is located in the St. Louis SMSA, is expected to have significant growth. The portion of the basin that is located in the St. Louis SMSA should be mainly residential with some activity in the commercial and light industry field. These residents' primary place of employment will be in the city of St. Louis. Therefore, for purposes of

this report, this growth for the lower Meramec River Basin was considered only in terms of population. Population projections for the lower portion of the basin were obtained principally from a recent report titled "The Meramec Basin," Water and Economic Development by the Meramec Research Project, Washington University, St. Louis, Missouri. The lower portion of the basin is expected to increase from approximately 92,000 in 1960 to about two million in 2070. The population of this portion of the basin will be entirely urban. The upper portion is expected to increase from about 120,000 in 1960 to about one million in 2070. Of this total 80,000 is expected to be rural and 920,000 urban. Refer to Figures V-1 and V-2.



WATER SUPPLY AND
WATER QUALITY CONTROL STUDY

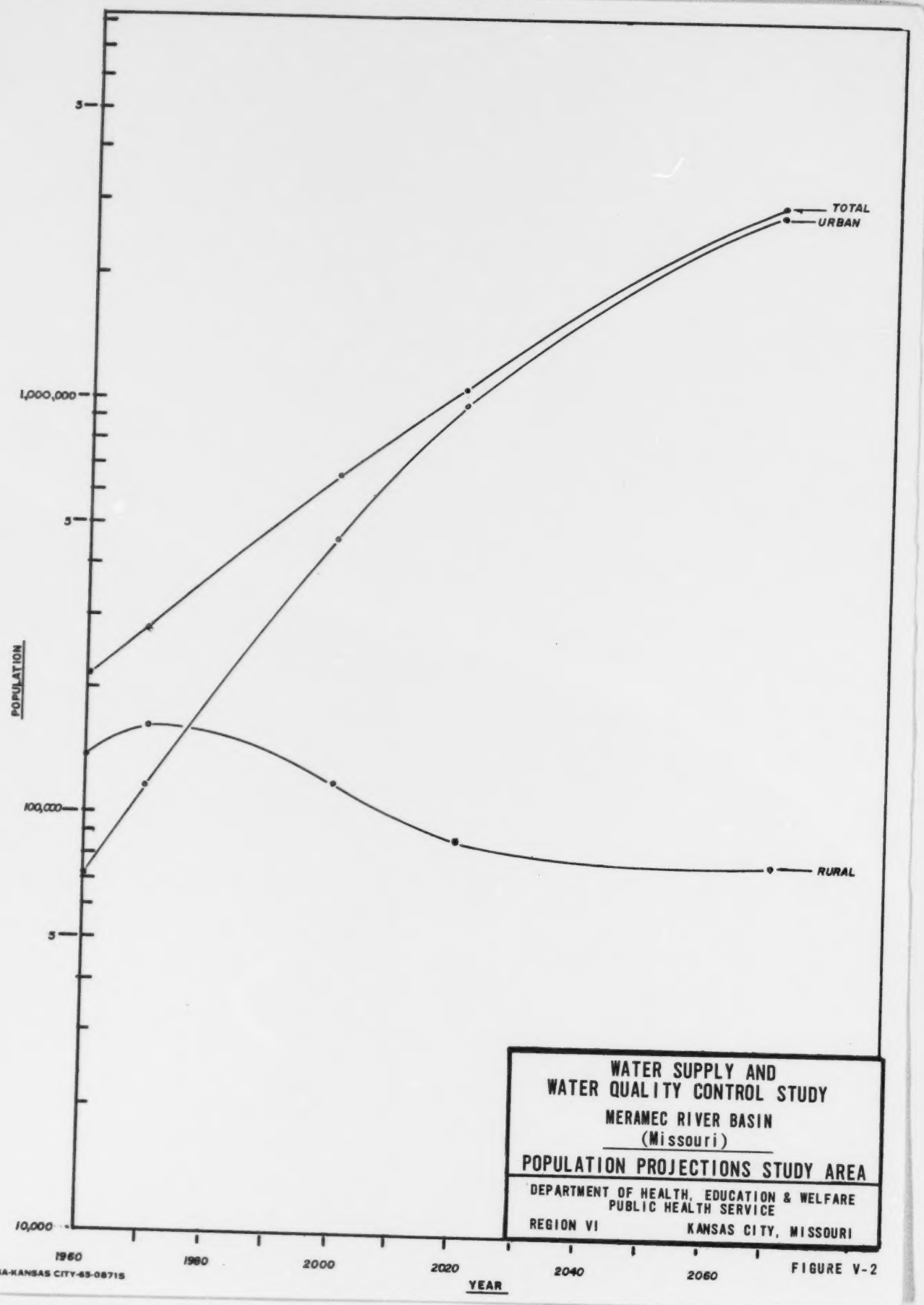
MERAMEC RIVER BASIN
(Missouri)

POPULATION PROJECTION COMPARISONS

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VI KANSAS CITY, MISSOURI

GSA-KANSAS CITY-65-0870S

FIGURE V-1



WATER SUPPLY AND
WATER QUALITY CONTROL STUDY

MERAMEC RIVER BASIN
(Missouri)

POPULATION PROJECTIONS STUDY AREA

DEPARTMENT OF HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VI KANSAS CITY, MISSOURI

GSA-KANSAS CITY-65-0871S

FIGURE V-2

VI. WATER RESOURCES

Surface Water

The streamflows in the Meramec Basin result from rainfall, runoff, pumpage of mine water, perennial springs, and ground water discharges. There are twenty major springs in the upper area which have a combined average discharge of 66 million gallons per day (mgd). (Refer to Exhibit No. 2). The largest spring, located on the Upper Meramec River, is the Meramec Spring, which discharges an average flow of 36 mgd; flows of other springs range from 0.26 mgd to 4.6 mgd.

In the southeastern part of the basin, dewatering of lead mines has increased the low flows in the Big and Meramec Rivers. In 1960, an average of 40 mgd was being pumped from the mines.

Streamflow data are available for ten U. S. Geological Survey stations located on the major streams. Limited streamflow data are available on the tributaries to the Meramec, Bourbeuse and Big Rivers. A method relating drainage area and streamflow was developed to obtain minimum flow and frequency data for the tributaries.

The quality of the surface water in the basin is satisfactory as a raw water source for municipal and most industrial purposes. The chemical concentrations are below the 1962 Public Health Service Drinking Water Standards (limits not to be exceeded). A partial chemical analysis of the untreated Meramec River water at Kirkwood, Missouri, is presented in Exhibit No. 3. However, water quality data are not available for all of the streams in the basin.

Ground Water

The basin has extensive ground water resources. The major aquifers in the basin are the Roubidoux, Gasconade, Potosi formations and the Gunder member of the Gasconade formation. Well production and depths, with reference to the water bearing formations, are presented in Exhibit No. 4.

The permissible increase of ground water usage for the Meramec Basin was determined by the State of Missouri, Division of Geological Survey and Water Resources. The report "Ground Water Use and Production Capabilities, Meramec River Basin, Missouri" by Dale L. Fuller, Senior Geologist, presents the permissible increase of ground water as a multiple of present usage based on area and population density. The range of permissible increase varies from 6 to 59 times present usage. The yield of ground water from deep formations in the extreme northeastern corner of the area is limited.

The major source of ground water in the lower reach of the Meramec River is the alluvial deposits known as the Meramec River bottoms. Information indicating the potential yield of the alluvial aquifer is not available.

The chemical quality of ground water is generally satisfactory with low concentrations of chlorides, sulfates, and iron in some of the waters. Chlorides range from 3.2 to 62 milligrams per liter (mg/l), iron from 0.01 to 0.3 mg/l and sulfates from 0.8 to 205 mg/l. Spring water is high in iron from 0.23 to 0.87 mg/l and in some cases

exceeds the Public Health Service Drinking Water Standards of 0.3 mg/l. The ground water ranges in hardness from 73 to 446 mg/l as $CaCO_3$. In the southesatern part of the basin, some of the water pumped from mines exceeds the Public Health Service upper limit of 500 mg/l total dissolved solids. The quality of water from the Bonne Terre mine is poor and is not currently being used for municipal or industrial purposes. The municipalities in the southern area using mine water could, by constructing wells, obtain a better quality ground water from the Lamotte formation. The chemical analyses of the public water supplies are presented in the Appendix. In general, the chemical concentrations in these public water supplies are below limits, not to be exceeded, of the 1962 Public Health Service Drinking Water Standards. Chemical analysis of the mine water and perennial springs are presented in Exhibits No. 7 and 8, respectively.

Summary of Water Analyses*

(Concentrations in Milligrams per Liter)

	Meramec River Bottoms	Mine Water	Spring Water
Total Dissolved Solids	420	486 & 922	--
Chlorides (Cl)	41	23 & 19	2.4 to 6.6
Sulfates (SO_4)	61	69 & 312	2.7 to 10.5
Hardness ($CaCO_3$)	267	-	124 to 221

*See Exhibits No. 6, 7 and 8 for additional data.

VII. MUNICIPAL AND INDUSTRIAL WATER SUPPLY NEEDS

Present

Water for municipal and industrial uses is the principal demand on the water resources of the Meramec River Basin. Municipal and industrial demands, not including mining uses, in 1960 were approximately 5 million gallons per day (mgd) in the upper area and 10 mgd in the lower area. The 1960 per capita use in the study area varied from 52 to 139 gallons per day and averaged 70 gallons per capita per day (gpcd) in the upper area and 110 gpcd in the lower area.

The municipalities in the Bourbeuse River Basin use ground water as a souce of supply. The municipality of Union which uses both ground and surface water sources has a new well capable of 600 gallons per minute, eliminating the need for the river water intake.

The municipal supplies in the Big River Basin are obtained from wells and mines. The Leadwood-Rivermines area uses approximately 1 mgd of mine water. Bonne Terre has abandoned its mine water supply because of poor chemical quality (total dissolved solids 922 mg/l, sulfates 312 mg/l and is using well water.

The municipalities in the lower area obtain water from the alluvial deposits and the Missouri and Meramec Rivers. A water treatment plant on the Missouri River supplies water to portions of the lower area, and a St. Louis County plant on the Meramec River provides a supplementary supply.

Additional information related to public water supplies in the

Meramec Basin is presented in Exhibit No. 9. This table summarizes the water supply source, treatment provided, population served, and consumption.

The lead mining operations in the southeastern part of the basin in dewatering the mines, pump approximately 40 million gallons of water per day. Six million gallons of this water is used daily for mining, milling and smelting operations.

Barite mining in the southeastern part of the basin uses approximately four million gallons of water per day in the mill washing operations. The demand is met from various sources including small impoundments on minor tributaries.

The iron mining operations in the central part of the basin use from 0.2 to 1.8 million gallons of water a day. There is not sufficient ground water to meet the demand. A pumping station on the Meramec River is being constructed approximately at river mile 110 to deliver 1.8 mgd to the Pea Ridge Mining area.

Future

The future water supply requirements for the Meramec River Basin will be for municipal, rural, and industrial purposes. The water needs are estimated for the years 1970, 2020 and 2070.

The increase in municipal and industrial water requirements during the study period is based on the population growth, industrial-

ization, commercialization, and development of new water using devices for the home. The lower area near the St. Louis SMSA is expected to have greater commercial and industrial development and a greater amount of water used per capita. The upper area is expected to have a steady industrial and commercial growth. The following table indicates the expected water use, from municipal systems, expressed in gallons per capita per day for the upper and lower areas. The figures shown include light water using industries and commercial establishments.

Table No. VII-1

Water Demand
(gpcd)

Meramec River Basin

	1970	2020	2070
Lower Area	120	150	200
Upper Area	100	130	160

These figures are consistent with value used in other studies of the area by private organizations and by other Federal and State agencies.

The municipal and industrial water demands for the upper area are supplied entirely from ground water sources and are expected to reach 32 million gallons per day (mgd) by 1970, 54 mgd by 2020, and 138 mgd by 2070. The present usage of ground water is approximately

16 mgd and according to a report prepared by the Missouri Geological Survey and Water Resources Division, the withdrawal of ground water may be increased to 280 mgd without depletion of the aquifers. Therefore the future demands can be met without requiring storage in the proposed reservoir system. Comparison of water use, surface versus ground water, indicated that ground water is more economical.

The municipal and industrial demands of the Lower Meramec Water Service Area are expected to reach 16 mgd by 1970, 93 mgd by 2020, and 400 mgd by 2070. The portions of the basin and St. Louis SMSA now served from the Missouri and Mississippi Rivers are expected to continue to be served from those sources and the quantity of water is expected to be sufficient to meet future needs of these areas. The remaining part of the lower area could obtain water from ground water sources, the Meramec River, or the Missouri River.

With the expansion of the present facilities in the lower area, a demand of 25 mgd could be met from ground water sources. By the year 2025 additional water will be needed to meet summer needs. By 2070 provision to supply as much as 345 mgd in addition to available ground supplies and natural low flows to secure a 98% assurance that needs can be met. The requirements could be met by pumping water from the Missouri River or by constructing reservoirs on the Big, Meramec, or Bourbeuse Rivers.

The water demands indicated for mining are average figures and large deviations can be expected because of the many factors which

affect production. The total average demand for mining operations in the basin is expected to reach 13 mgd by 1970 and reach a maximum of 20 mgd by 2000. After 2000, some of the mining operations are expected to phase out.

The water requirements for a barite mining operation, which produced about 100 tons of barite concentrates per 24-hour day, are about 1,000 to 1,200 gallons per minute (gpm); however, the majority of the water is recirculated and the net water demand is approximately 0.6 mgd. The water needs are expected to reach 5 mgd by 1970 and 6 to 7 mgd by 2000. After 2000, the barite operation will be phasing out, with little or no water demand by 2020. The demands can be met from ground water sources or from small private surface water impoundments.

Water requirements for the lead mining operations are expected to reach 7 mgd by 1970 and 10 mgd by 2000. The indicated water requirements are the net water demands which amount to about 15 percent of the total water requirements. Dewatering of the mines will provide an excess of water. After 2000, the lead mining will be phased out.

The iron mining operations in the basin will increase throughout the study period. The water requirements are expected to reach 1 mgd by 1970, 4 mgd by 2020 and 8 mgd by 2070, assuming no recirculation. If the water is recirculated, the net new water needs would be from 10 to 30 percent of the amounts shown. The demand could be met from

ground water sources with the exception of the Pea Ridge Area, which requires a supplemental water source. Pumping facilities are being installed to supply this area with water from the Meramec River. The present flow in the Meramec River is adequate without reservoirs to meet the present and future water requirements of the iron mining operations.

A 300 ton per day pulp mill is expected to be established in the southeastern part of the basin by 1970.[40/] The mill will require approximately 9 mgd which will remain constant for the study period. The demand can be met by using water from the mines.

The most significant recreation areas will be at the Virginia Mines and Meramec Park Reservoirs. According to information provided by the Bureau of Outdoor Recreation and the U. S. Army Corps of Engineers, the number of visitors on the peak day is expected to reach 182,000 by 1970, 260,000 by 2020, and 410,000 by 2070. Assuming ten gallons per visitor per day [39/] the demand will be about two mgd by 1970, three mgd by 2020, and four mgd by 2070. Wells located at the recreational sites could supply sufficient water to meet these needs. The impact of recreation in the basin is not expected to create any water supply problem.

Value of Municipal and Industrial Water Supply

In the upper area, water supply needs could be met from well

systems or from reservoirs. A cost analysis was made for treated ground water and treated surface water assuming surface water is available at no cost at the treatment plant intake. Total estimated costs for obtaining and treating ground water were less than the treatment costs connected with the use of surface water. Therefore, no storage in Federal reservoirs for municipal and industrial water supply is recommended for this area. See Exhibit No. 10 in the Appendix.

In the lower area, the future municipal and industrial water supply needs could be met by obtaining water from the upstream reservoirs or the Missouri River. There will be a need for more water by the year 2025.

Three alternatives for obtaining the needed municipal and industrial water supply in the lower area were considered. Treatment costs of Meramec River water and Missouri River water are assumed to be equal because the chemical quality of the waters is similar. The alternatives are given below.

A. Transmission of Missouri River water to supply the total 2070 municipal and industrial water supply need in the lower area as required.

B. A single purpose reservoir above reach M-7 capable of assuring an additional 345 mgd to meet the 2070 municipal and industrial water supply needs.

C. The transmission of a sufficient quantity of water from the Missouri River to make up the deficiency between the projected municipal and industrial demands and the available supplies in the lower area. See Exhibit No. 10 in the Appendix.

Costs of each alternative are compared in Exhibit No. 10 in the Appendix. Provision of a single purpose reservoir in the Meramec River Basin, alternative B, was found to be the most economical alternative. Its value, used as the value of storage for municipal and industrial water supply, is $107,000 per year.

VIII. STREAMFLOW REGULATION FOR WATER QUALITY CONTROL

General

Under provisions of the Federal Water Pollution Act, Public Law 84-660 as amended by P. L. 87-88, in the survey or planning of a reservoir by any Federal agency, consideration must be given to the inclusion of storage for regulation of streamflow for the purpose of water quality control. The law expressly states that any such storage and water releases shall not be provided as a substitute for adequate treatment or other methods of controlling wastes at their sources.

Discharge of wastes, even when treated to the maximum extent technically practical and economically feasible, will cause an unsatisfactory quality condition in receiving waters whose waste assimilation capacity is exceeded. This condition usually, but not always, occurs during periods of low flows and may be avoided by the addition of water to maintain flows at higher levels. Recognition must be given to the need for required flows in receiving streams if the water quality is to be maintained at acceptable levels.

The quality objectives are based on total dissolved solids (TDS), sulfates (SO_4), chlorides (Cl), and dissolved oxygen (DO). The limiting concentrations for TDS, SO_4, and Cl are those stated in the 1962 Public Health Service Drinking Water Standards of not greater than 500, 250, and 250 mg/l, respectively. The dissolved oxygen content of water in the stream should not be less than 5.0 mg/l in

accordance with the objectives of the Missouri Basin Engineering Health Council.

Basic data indicating the present sources of domestic and industrial pollution appear in the Appendix as Exhibit No. 11.

Present

Based on projected economic activity mineral solids concentrations will continue to meet U. S. Public Health Service Drinking Water Standards and water quality control to maintain these objectives will not be required. (Note: In the absence of allocation of storage for irrigation no consideration has been given to the effects of irrigation return flows on water quality.)

Stream reaches between points of discharge of municipal wastes are too short in the stretch of the Meramec River from Pacific, Missouri, to its confluence with the Mississippi River for effective recovery from the effects of organic wastes by natural processes. As populations increase so will quantity of waste discharged. Even with adequate treatment* waste residuals reaching the river will exceed its assimilative capacity by 1985 to the point that a dissolved oxygen concentration of 5 mg/l cannot be maintained under critical conditions. Considering the downstream water uses a degree of protection of 95 percent (based on a 5 percent probability of available flows being less than that required) has been

*Adequate treatment is considered to be the equivalent of 85 percent removal of biochemical oxygen demand.

used to estimate water quality control storage needs.

Future

The major contributors are expected to be the potential pulp mill and municipalities. The largest waste loads discharged to the streams would be in the lower area. Few waste problems are expected from recreation and mining operations. Flow regulation needs are based on adequate treatment of all wastes.

In the mining industry, the wastes are primarily from wash waters and consist of colloidal silts and clay. Large sedimentation ponds remove most of the sediment before the waste water is discharged to the streams. Organic chemicals are used for the flotation process in the lead mining operations; however, the liquid is recirculated and the chemicals are not discharged to the streams.

The wastes from the proposed pulp mill will be primarily organic and the load on receiving waters is expressed in terms of biochemical oxygen demand (BOD). Treatment should reduce the mill wastes from 25,000 pounds of BOD (5 days at 20^{o} C) to 1,250 pounds of BOD per day. The treated wastes will be discharged to the Big River at approximately river mile 100. The treatment will consist of lagooning the wastes. The pulp mill wastes are not expected to contain components toxic to fish life.

Streamflow needs were determined for specific reaches of the

major streams for the spring, summer, fall and winter seasons. No water releases were considered from the headwater reservoirs because of their limited storage capacities.

The regulation requirements were also based on the assumption that the municipalities of Cuba, Potosi, Rolla, Salem, and Viburnum will discharge their wastes below planned reservoirs.

Considering quality control needs, municipal returns, and natural runoff (equal or exceeded 95 percent of the time), the annual draft on storage needed in 2070 to maintain the quality objectives in the reaches where there are quality control needs have been evaluated as shown in Table VIII-1. A schematic diagram of the river systems with reaches is shown in Figure No. VIII-1.

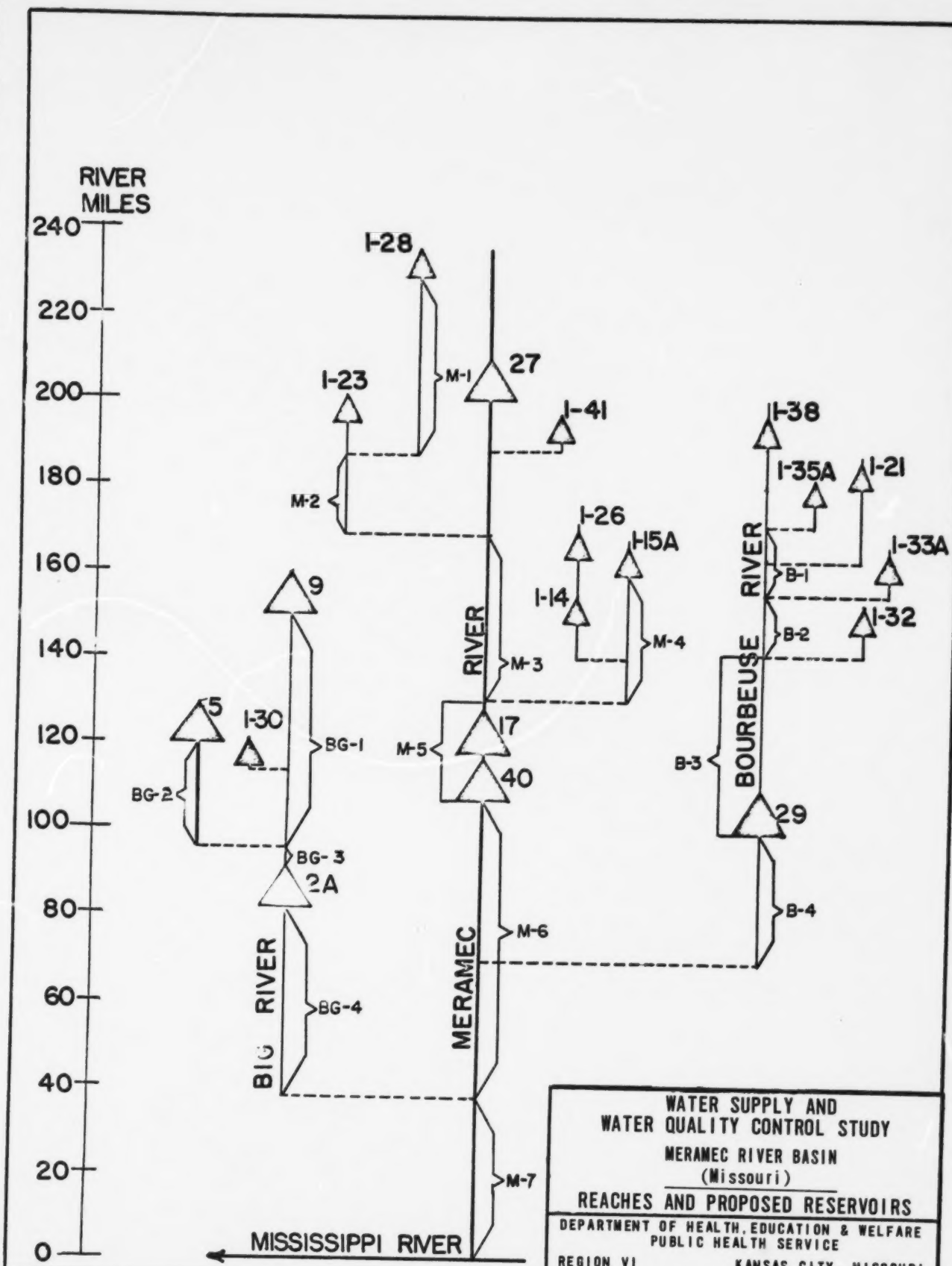
Table No. VIII-1

Summary of Net Regulation Requirements in Acre-Feet in 2070

Meramec River Basin

Stream Reach	Draft-on-Storage
B-1	
B-2	14,900
B-3	
M-1	
M-2	14,700
BG-1	26,600
M-7*	900,000*

*Consider carry over storage



WATER SUPPLY AND
WATER QUALITY CONTROL STUDY

MERAMEC RIVER BASIN
(Missouri)

REACHES AND PROPOSED RESERVOIRS

DEPARTMENT OF HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE

REGION VI KANSAS CITY, MISSOURI

SA-KANSAS CITY-65-08725

FIGURE VIII-1

Flow regulation should be based on adequate water quality monitoring. Most of the streamflow regulation for quality control will be needed during the summer months.

In the Bourbeuse River the needs for quality control regulation extend from the mouth of Dry Fork to just above the proposed reservoir No. 29. The draft-on-storage for reaches B-1, B-2, and B-3 as shown in Table No. VIII-1 should be provided above the confluence of Dry Fork with the Bourbeuse River by the year 1990.

In the upper Meramec the needs for quality control regulation occur at the head of reach M-1 and near both ends of reach M-2. The draft-on-storage for reaches M-1 and M-2 as shown in Table No. VIII-1 should be provided above the head of reach M-1 by the year 1990.

In the Big River the needs for quality control regulation all occur in reach BG-1. The draft-on-storage as shown in Table No. VIII-1 should be provided above the head of reach BG-1 by the year 1970. By approximately the year 1985, there will be a need for quality control regulation in the lower area of the meramec River Basin, occurring in the middle of reach M-7. The draft on storage as shown in Table No. VIII-1 should be provided above the middle of reach M-7. Some problems may arise from pollution loads entering the reservoirs and special studies or investigations may be needed.

Benefits

Benefits attributable to storage for streamflow regulation for

water quality control may be tangible, i.e., may have a measurable dollar value or may be intangible with no measurable dollar value. Water quality control management by the proposed reservoirs in the Meramec River basin will provide tangible benefits from recreational use of approximately 450 river miles of the stream from the dams to the confluence of the Meramec River with the Mississippi River below St. Louis, Missouri. Assured water quality will provide favorable conditions for recreation such as swimming, water skiing, boating and fishing in the Meramec River basin. The total population of the study area is estimated to be in the order of 3,000,000 by 2070. It is not unreasonable to anticipate that the total population in the study area, plus all the people located in the St. Louis SMSA, will be able to enjoy the recreational opportunities offered.

With the exception of a few private lakes and minor developments along the natural streams, there are very few water-based recreational facilities in the Meramec River Basin. The thirty-one proposed reservoirs would provide a total water surface area of approximately 51,200 acres at normal pool level. Recreational demands and percentage of demands that can be met by the 31 reservoirs were estimated by the Corps of Engineers. These demands are based on population growth within the zone of influence and reflect increased demands generated by reservoirs over and above those projected without improvements. Reservoir-associated recreation demands, less hunting and fishing, are estimated at approximately 19,000,000 visitor-days by 1970, 26,500,000

by 2020, and in excess of 37,000,000 visitor-days by the year 2070. The 31 reservoirs can support approximately 11,500,000 visitor-days by 1970, 16,000,000 visitor-days by 2020, and nearly 26,000,000 by the year 2070, provided adequate recreational facilities are constructed by Federal, State, and local governments, as well as private enterprise.

According to the Fish and Wildlife Service, present fisherman-use along project-affected reaches in the basin exceeds 230,000 angler days annually. Total demands for fishing were estimated by the Corps of Engineers for 1970 and projected for selected years from 1970 through 2070. These demands are based on population growth within the zone of influence and reflect increased demands generated by the reservoirs, with attendant improved stream fishery, over and above the demands without improvements. Reservoir and stream fishermen demands are estimated at approximately 3,400,000 fisherman-days in 1970, 4,700,000 fisherman-days in 2020, and slightly less than 6,700,000 fisherman-days by the year 2070. Demands which can be met by the 31 reservoirs, angler-use sites, and improved channel flow are estimated at approximately 2,000,000 fisherman-days by 1970, 2,300,000 fisherman-days by 2020, and 2,700,000 fisherman-days by the year 2070.

In addition to recreational benefits, and falling into the intangible benefit category, riparian property owners will enjoy improved esthetics of the stream stemming from clean surface waters. Availability of water of more uniform quality, as well as quantity, is a strong attraction to water-using industries, hence, industrial growth will be favored.

It is entirely possible that impoundments will have a beneficial effect on the mineral solids content of the waters of the controlled streams, which could lower treatment costs. From the above, it is concluded that benefits are widespread and general in nature, and warrant the provision of storage for the required streamflow regulation. These benefits may be credited to storage for the regulation of streamflow for water quality control purposes only if assurance is given that adequate treatment will be provided.

If required storage for streamflow regulation is not provided as recommended, water treatment cost in the area may be expected to increase, damage to paint on structures adjacent to or in the streams may be anticipated and property values will decline in areas contiguous to the streams. Lacking a water supply of assured quality as well as quantity, industry will be less likely to select plant sites in the basin, all other things being equal, which means economic growth in the portions of the study area will be restricted. Recreation will suffer. Without streamflow regulation it is estimated that the projected waste loads of 28,000 pounds BOD per day will result in a dissolved oxygen concentration in the lower Meramec River in reach M-7 as low as 2.0 mg/l in five percent of the years by 2010. This means that aquatic life such as fish will leave the area in favor of waters that more nearly provide the environment they require. By approximately 2030 waste loads will have increased until the dissolved oxygen will reach zero, no fish will be found in the lower stretch of the river, which will become the source of noxious odors and paint

blackening fumes on occasions, and will be worthless for recreational purposes. As waste loads continue to increase, conditions in the receiving streams will continue to worsen. Unless adequate treatment is supplemented by streamflow regulation, unsatisfactory conditions will occur in the upper area in river reach BG-1 by 1970, and reaches M-1, M-2, B-1, B-2 and B-3 by 1990.

Value of Benefits

When no adequate means can be devised to evaluate directly the economic effects of water quality maintenance or improvement, the cost of achieving the same results by the most likely alternative may be used as an approximation of value. In determining the "most likely alternative" several possibilities have been studied.

Upper Area

Wells were considered, in the six upper reaches (M-1, M-2, B-1, B-2, B-3 and BG-1), as an alternative to storage. These wells would each have to have an aerator and a pump with an estimated life of 25 years. The capital cost of wells was found to be higher than the capital cost of single purpose reservoirs to supply the needed quality control water.

A combination of holding ponds and single purpose reservoirs in the upper area is also a possible alternative. Past experience has shown that the capital costs of the combinations of waste storage and stream storage closely approximate the cost of single purpose reservoirs. Single purpose reservoirs, therefore, are considered the most feasible alternatives for evaluation of quality control benefits in the upper area.

A single purpose reservoir above reach BG-1 to supply a draft-on-storage of 26,600 acre-feet per year is the most feasible alternative for quality control for reach BG-1. The site of the proposed Corps of Engineers Reservoir No. 9 seems the most likely location for this single purpose reservoir, with regulation needed for quality control in 1970. See Table No. VIII-2 for a sample distribution of reservoir releases required. The average annual value of benefits for quality control storage beginning in 1970 is $253,900 based on the cost of this single purpose reservoir including operation and maintenance costs.

Table No. VIII-2

A Sample Distribution of Monthly Mean Reservoir Releases for Quality Control Above Reach BG-1
(mgd)
(Not an Operating Schedule)
Meramec River Basin

Month	1970	2020	2070
April	0	1	6
May	0	1	6
June	27	39	64
July	31	47	72
August	31	48	76
September	32	50	81
October	0	6	9
November	0	4	7
December	0	0	1
January	0	0	1
February	0	0	1
March	0	0	[illegible]

A single purpose reservoir above reach M-1 is the most feasible alternative to supply the draft-on-storage of 14,700 acre-feet per year needed for quality control in reaches M-1 and M-2. The most feasible location for this single purpose reservoir seems to be the site chosen for the proposed Corps of Engineers Reservoir I-28. See

Table No. VIII-3 for a sample distribution of reservoir releases required. The annual value of benefits of quality control regulation which is first needed in 1990 is $119,200, based on the average annual cost of the single purpose reservoir, including operation and maintenance costs.

Table No. VIII-3

A Sample Distribution of Monthly Mean Reservoir Releases for Quality Control Above Reaches M-1 and M-2
(mgd)
(Not an Operating Schedule)
Meramec River Basin

Month	1970	2020	2070
April	0	0	0
May	0	0	0
June	0	0	23
July	0	2	41
August	0	7	45
September	0	9	48
October	0	0	2
November	0	0	0
December	0	0	0
January	0	0	0
February	0	0	0
March	0	0	0

A single purpose reservoir above reach B-1 to supply a draft-on-storage of 14,900 acre-feet per year needed for quality control in reaches B-1, B-2 and B-3 is the most feasible alternative. This reservoir will be needed by the year 1990 and would be most likely located at the site of the proposed Corps of Engineers Reservoir I-38. See Table No. VIII-4 for a sample distribution of reservoir releases required. The average annual value of benefits of quality control regulation in reaches B-1, B-2 and B-3 is $96,200 based on the average annual cost of this reservoir, including operation and maintenance costs.

Table No. VIII-4

A Sample Distribution of Monthly Mean Reservoir Releases for Quality Control Above Reach B-1
(mgd)
(Not an Operating Schedule)
Meramec River Basin

Month	1970	2020	2070
April	0	0	0
May	0	0	0
June	0	0	0
July	0	0	27
August	0	9	49
September	0	12	52
October	0	4	22
November	0	0	13
December	0	0	0
January	0	0	0
February	0	0	0
March	0	0	0

Tables VIII-2, VIII-3 and VIII-4 indicate the maximum releases required for quality control in the upper area. These are not operating schedules, but are sample distributions of reservoir releases and are provided to indicate typical release patterns.

The capital cost figures and amortization rates for the three single purpose reservoirs for the upper area are shown in Exhibit No. 12. The total average annual alternative costs for supplying quality control needs in the upper area is $469,300, including operation and maintenance costs.

Lower Area

In the lower area, there is not sufficient ground water to supply the quality control needs in the lower reach. A holding pond would not be feasible in the future in the highly urbanized lower area.

Three single purpose reservoirs to supply the needed 900,000 acre-feet of draft on storage were considered as a possible alternative. These single purpose reservoirs were located at the sites of the proposed major Corps of Engineers Reservoirs and the first project was needed in 1985.

Table No. VIII-5
A Sample Distribution of Montly Mean Reservoir Releases for Quality Control Above Reach M-7
(mgd)
(Not an Operating Schedule)
Meramec River Basin

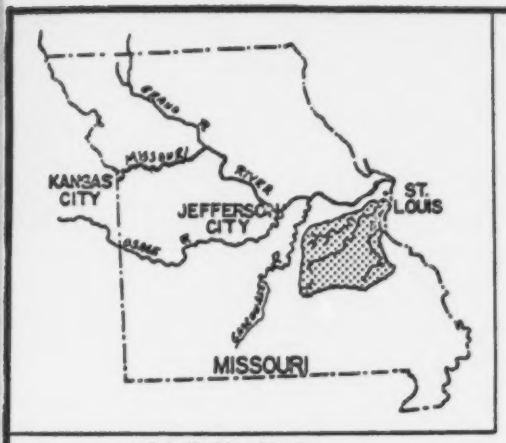
Month	1970	2020	2070
April	0	2	10
May	0	1	9
June	0	13	711
July	0	73	878
August	0	112	915
September	0	139	939
October	0	9	161
November	0	8	80
December	0	0	0
January	0	0	0
February	0	0	0
March	0	0	0

Table VIII-5 indicates the maximum releases required for quality control in the lower area. This is not an operating schedule, but is a sample distribution of reservoir releases and is provided to indicate a typical release pattern.

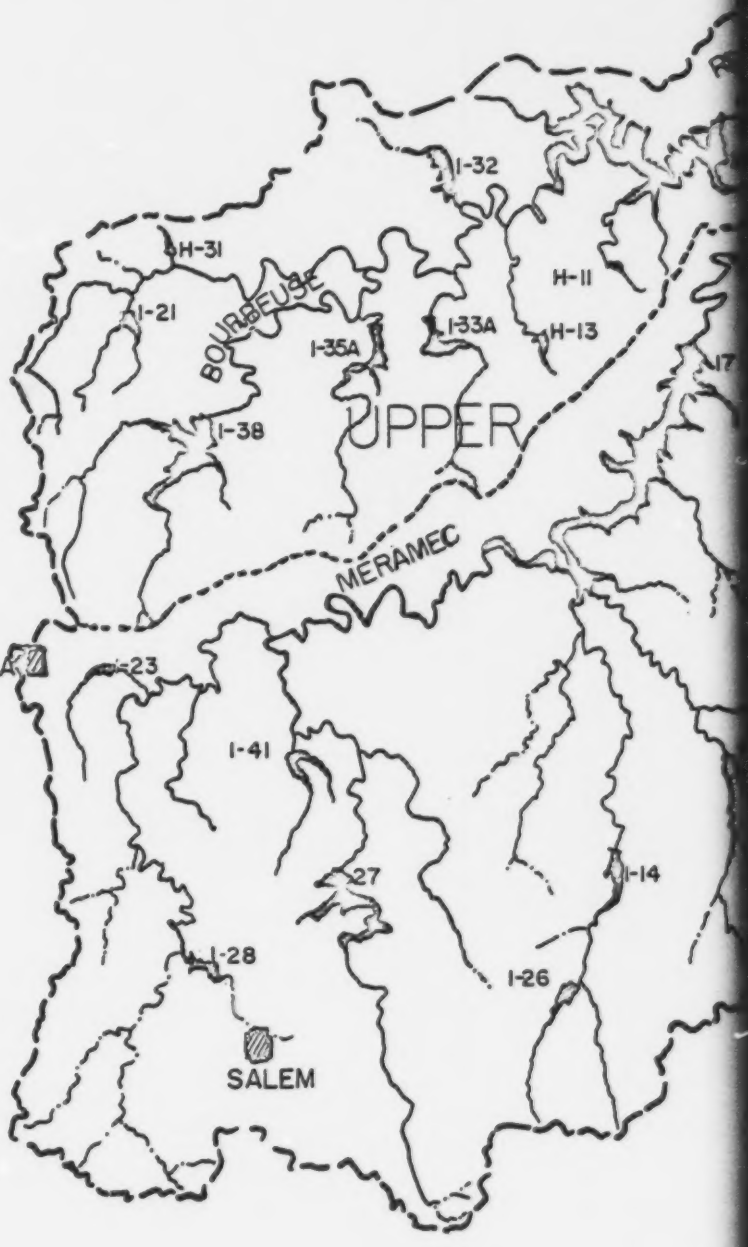
The most likely alternative was found to be pumping part of the treated wastes 19 miles to the Mississippi River where sufficient flow is available to satisfactorily assimilate the treated wastes, plus

provision of a single purpose reservoir to regulate flows to prevent problems from urban and rural runoff. The cost was based on pumping only that portion of the treated wastes that could not be satisfactorily assimilated by the uncontrolled streamflow in the Meramec River. Therefore, the annual value of storage for quality control regulation is the annual transmission cost of the treated waste to the Mississippi River plus the cost of supplemental storage for streamflow regulation which is $595,500.

Exhibit No. 13 shows the calculation of this annual value and its comparison to the single purpose reservoir cost.



LOCATION MAP



LEGEND

7- MAJOR RESERVOIR
I-12- INTERMEDIATE RESERVOIR
H-12- HEADWATER RESERVOIR

MUNICIPALITIES

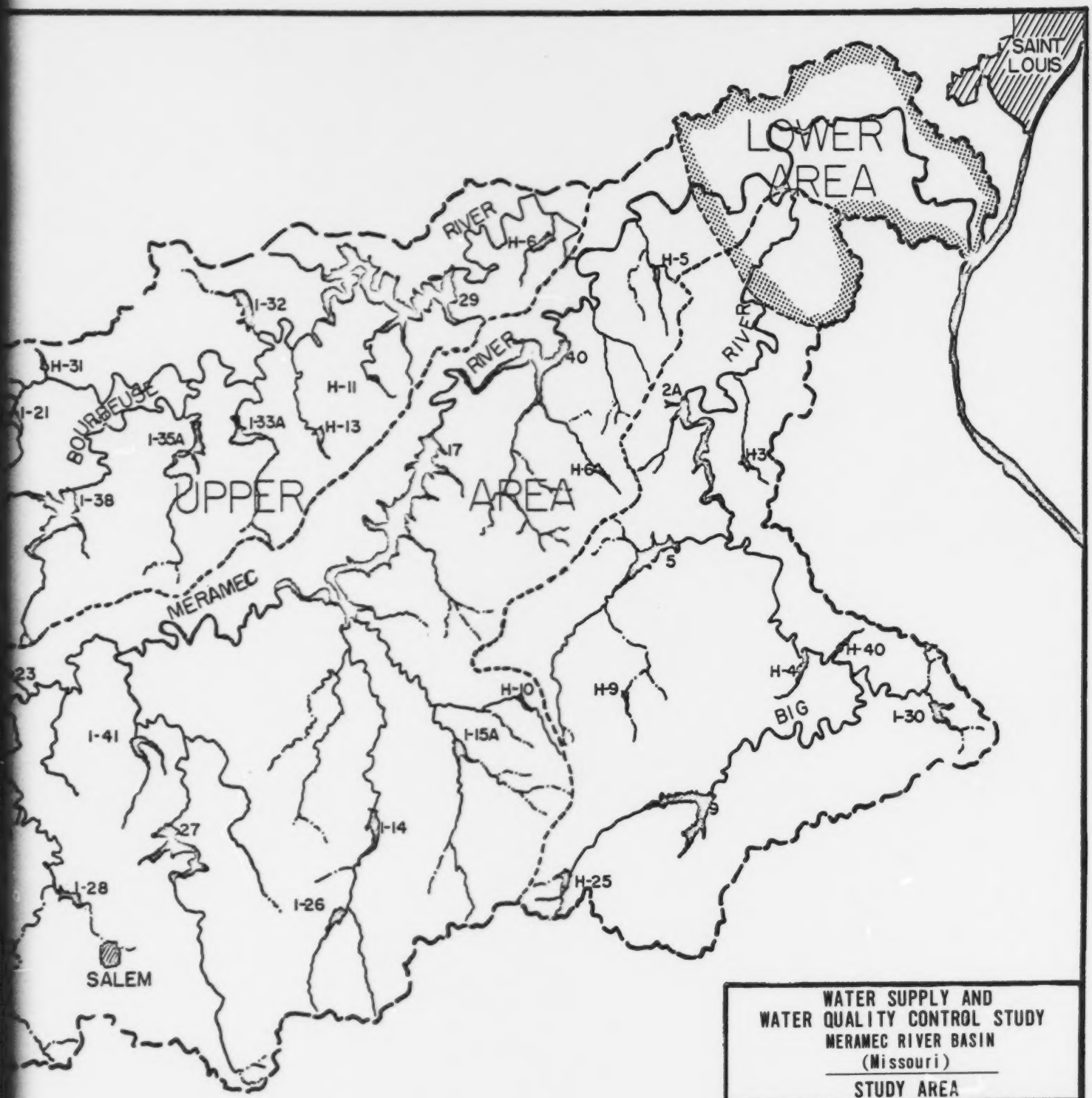
BASIN BOUNDARY

SUBBASIN BOUNDARY

STATE LINE

0 5 10 15 20 25
SCALE IN MILES

GSA-KANSAS CITY-65-0954H



WATER SUPPLY AND
WATER QUALITY CONTROL STUDY
MERAMEC RIVER BASIN
(Missouri)

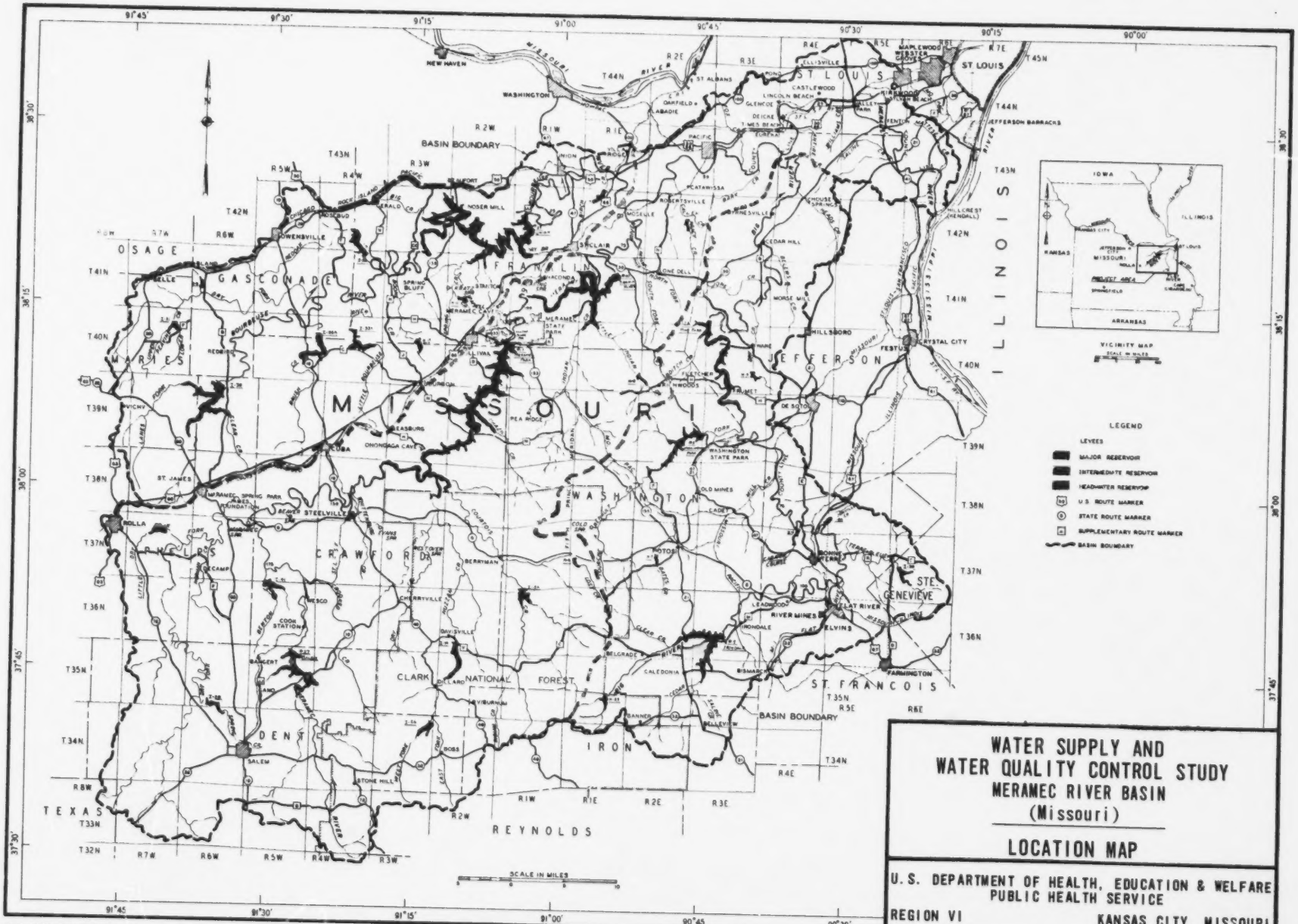
STUDY AREA

DEPARTMENT OF HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VI KANSAS CITY, MISSOURI

FIGURE VIII-2

Basin Boundaries and Proposed Reservoirs

B



WATER SUPPLY AND WATER QUALITY CONTROL STUDY
MERAMEC RIVER BASIN
(Missouri)

LOCATION MAP

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VI KANSAS CITY, MISSOURI

GSA-KANSAS CITY-65-08695

FIGURE VIII-3

IX. BIBLIOGRAPHY

BIBLIOGRAPHY

1. U.S. Bureau of the Census, U.S. Census of Population, 1940,1950, 1960, Volume II, "Characteristics of the Population," U.S. Government Printing Office, Washington, D.C., 1942, 1952,1961

2. Unpublished data, U.S. Forest Service, Milwaukee, Wisconsin

3. Unpublished data, U.S. Bureau of Mines, Bartlesville, Oklahoma

4. U.S. Bureau of Mines, Minerals Yearbook: 1953,1955,1957,1960, Volume III, "Area Reports," U.S. Government Printing Office, Washington, D.C., 1954,1956,1958,1960,1961

5. U.S. Bureau of the Census, U.S. Census of Agriculture: 1949,1955, 1959, Volume I, U.S. Government Printing Office, Washington, D.C., 1950,1956,1961

6. U.S. Bureau of the Census, U.S. Census of Population: 1930,1960, Volume I, "Number of Inhabitants," U.S. Government Printing Office, Washington, D.C., 1931,1961

7. Meramec Basin Corporation, Explanatory Note and Background on the Meramec Basin Cooperative Planning Committee, January 1962, Washington University Press, St. Louis, Missouri, 1962

8. Corps of Engineers, Formation of a Plan of Development, Meramec River Basin, Missouri, April 1962, Army Engineer District, St. Louis, 1962

9. Corps of Engineers, Formation of a Plan of Development, Meramec River Basin, Missouri, Colonel Alfred J. D'Arezzo, Army Engineer District, St. Louis, 1962

10. Meramec Basin Research Project, The Meramec Basin Water and Economic Development Report, Vol. 2 of 3, February 1962, E.L. Ullman, R.R. Boyce, D.J. Volk, Washington University Press, 1962

11. Meramec Basin Research Project, The Meramec Basin Water and Economic Development Report, Vol 3 of 3, February 1962, E.L. Ullman, R.R. Boyce, D.J. Volk, Washington University, St. Louis, 1962

12. Harland Bartholemew and Associates, A Comprehensive Plan of Flat River, Missouri, December 1961, Harland Bartholomew and Associates, St. Louis, 1961

13. Meramec Basin Research Project, The Outlook for Municipal and Industrial Water in the Meramec River Basin and St. Louis Area, July 1961, Washington University Press, St. Louis, 1961

BIBLIOGRAPHY (cont'd)

14. Bureau of Mines, Minerals Yearbook,1960, "The Minerals Industry in Missouri", U.S. Government Printing Office, Washington, D.C., 1960

15. Meramec Basin Research Project, Status of Municipal Sewage Disposal, Meramec River Basin as of November 23, 1960, Washington University Press, St. Louis, 1961

16. Public Health Service, Summary Report on Effluent Disposal Considerations of Possible Pulp and Paper Mill Developments in Southwestern Missouri, U.S. Government Printing Office, Kansas City, 1960

17. Harland Bartholomew and Associates, Land Development Studies, Washington County, Missouri, December 1960, Harland Bartholomew and Associates, St. Louis, 1961

18. Environmental Motivation Sanitation Survey, Staff Members of Jefferson County Health Department and DeSoto City Employees, with officials of the City of DeSoto, City Planning Commission, Missouri State Division of Health and the United States Public Health Service, June 1960

19. Meramec Basin Research Project, Summary and a Program of Water Development Proposals, March 1962, Washington University Press, St. Louis, 1962

20. Public Health Service, A Comprehensive Program for Water Pollution Control for the Meramec River Basin, 1957, U.S. Government Printing Office, Kansas City, 1957

21. Summary Report on the Meramec River Cooperative Investigation Field Committee, August 1949, Agencies of the State of Missouri and Agencies of the United States Government

22. Corps of Engineers, Multiple Purpose Reservoirs, Meramec Basin, September 1949, Army Engineer District, St. Louis, 1949

23. Recreational Section, Missouri Division of Resources and Development, Recommendations of the Missouri Division of Resources and Development on Recreational Development of the Meramec River Basin, July 1948, State of Missouri Printing Plant, Jefferson City, 1948

24. U.S. Department of Agriculture, Soil Conservation Service, A Study of Small Upland Reservoirs in the Meramec River Basin, June 1946, U.S. Government Printing Office, Washington, D.C., 1946

25. Missouri Division of Health, Division of Public Health Engineering, Meramec River Pollution Study, 1943, State of Missouri Printing Plant, Jefferson City, Missouri, 1943

BIBLIOGRAPHY (cont'd)

26. U.S. Department of Agriculture, Bureau of Agricultural Economics, Preliminary Examination Report of Runoff and Waterflow Retardation and Soil Erosion Prevention for Flood Control, June 1942, U.S. Government Printing Office, Washington, D.C., 1942

27. Missouri State Planning Board, Water Resources Committee, Meramec River Basin of the Lower Mississippi River Drainage Basin, August 1936, Missouri State Printing Plant, Jefferson City, 1936

28. Missouri Geological Survey, Appendix V, 58th Biennial Report, 1935, "Underground Waters in St. Louis County and St. Louis City, Missouri" Missouri State Printing Plant, Jefferson City, 1935

29. U.S. Geological Survey, Geological Survey Circular No. 216, 1952, "Water Resources of the St. Louis Area, Missouri and Illinois," U.S. Government Printing Office, Washington, D.C., 1952

30. U.S. Geological Survey, Water Supply Paper No. 1711, 1962, "Surface Water Supply of the United States," U.S. Government Printing Office, Washington, D.C., 1962

31. Missouri Division of Health, Census of Public Water Supplies in Missouri, 1962, Missouri State Printing Plant, Jefferson City, 1962

32. Missouri Geological Survey and Water Resources, Large Springs in Missouri, 1944, Missouri State Printing Plant, Jefferson City, 1944

33. Work Project Administration, A State Plan for Missouri, 1938, U.S. Government Printing Plant, Washington, D.C., 1938

34. From River to You, St. Louis County Water Company, 1960

35. Division of Mineral Resources, U.S. Bureau of Mines, Region IV, Data on Present and Future Mineral Resources and Mineral Industry of the Meramec River Basin, Missouri, 1963, U.S. Government Printing Office, Washington, D.C., 1963

36. National Park Service, Preliminary Recreation Analysis, Meramec River Basin, Missouri, 1963, National Park Service, Midwest Regional Office, Omaha, 1963

37. Groundwater in the Meramec Basin of Missouri, 1961, Robert D. Knight, Missouri Geological Survey, 1961

38. Groundwater Use and Production Capabilities, Meramec River Basin, Missouri, 1963, Dale L. Fuller, Missouri Geological Survey, 1963

39. Environmental Sanitation, Joseph A. Salvator, University of California Press, Berkeley, 1958

BIBLIOGRAPHY (cont'd)

40. Report on Forest Resource Potential (Preliminary), 1962, A.L. Richey, K.A. Davidson, U.S. Forest Service, Milwaukee, 1962

41. Unpublished data, Corps of Engineers, Army Engineer District, St. Louis, Missouri, 1963

42. Letter from Corps of Engineers, Army Engineer District, St. Louis, dated 7 February 1963, Reference: LMLED-PE, regarding "Advisory Action No. 4"

Appendix

Exhibit No. 1

* RESERVOIR DATA

Meramec River Basin

RESERVOIR	FLOOD CONTROL POOL STORAGE (Acre-Feet)	100-YEAR SEDIMENT STORAGE (Acre-Feet)	NET STORAGE JOINT-USE POOL (Acre-Feet)	TOTAL STORAGE (Acre-Feet)
I-14	27,500	4,000	3,900	35,400
I-15A	29,600	4,800	3,600	38,000
I-21	6,300	1,600	700	8,620
I-23	-	2,100	10,600	12,700
I-26	4,600	1,800	19,600	26,000
I-28	11,800	2,500	11,700	26,000
I-30	2,700	1,500	2,900	7,100
I-32	-	3,000	23,000	26,000
I-33A	-	2,700	23,300	26,000
I-35A	-	3,300	22,700	26,000
I-38	29,600	4,700	4,700	39,000
I-41	7,700	1,900	700	10,300
H-3	1,850	670	230	2,750
H-4	-	650	1,430	2,080
H-5A	640	230	80	950
H-6	-	730	2,030	2,760
H-8	2,840	1,040	2,080	5,960
H-9	1,430	620	190	2,240
H-10A	670	430	140	1,240
H-11A	1,880	820	350	3,050
H-13A	4,170	1,060	350	5,580
H-25	700	870	1,090	2,660
H-31	-	510	1,250	1,760
H-40	-	380	520	900

* Revised figures furnished by the Corps of Engineers, St. Louis, Missouri on August 28, 1964.

Exhibit No. 2

Spring Flows from Large Privately Owned Springs *

Meramec River Basin

Spring Number	Spring	River Miles ** Above Mouth	Discharge Million Gallons/Day
54	Kratz	64-40-15	4.39
107	McDade	64-110-30	0.52
78	Roaring	95	0.65
15	Blue	118	3.17
65	Onondage	130	0.77
50	James	132-6	1.43
92	Westover	132-5-3	4.07
96	Woodlock	132-25	1.30
36	Evans	140-4	0.26
30	Collins	140-8	1.03
59	McIntosh	152	0.61
77	Roaring	158	2.65
76	Richart	160	0.81
21	Brook	165	0.40
60	Meramec	165	36.2
109	Mint	200	0.39
48	Howes Mill	200-25	4.59
100	Cold	37-62-25	0.45
73	Racing	37-62-30	1.51
47	Hopewell	37-70-10	1.31

* From Missouri Water Resources Map
** River mile prefix of 37 indicates The Big River and 64 indicates the Bourbeuse River.

Exhibit No. 3

Chemical and Physical Characteristics of Untreated Meramec River Water at Kirkwood, Missouri **

Meramec River Basin
(yearly averages)

Year	Temperature (° F)	Turbidity (mg/l)*	pH	Alkalinity as $CaCO_3$ (mg/l)*	Hardness as $CaCO_3$ (mg/l)*
1940	60	66	8.0	159	184
1941	63	73	8.0	142	174
1942	61	137	8.0	140	178
1943	62	87	8.1	156	196
1944	61	83	-	162	188
1945	58	112	7.9	147	179
1946	62	89	7.9	148	194
Average	61	92	8.0	150	185

* Milligrams per liter
** From Geological Survey Circular 216, 1952

Exhibit No. 4

Well Data

Meramec River Basin

Formation and Well	County	Total Depth Feet	Production (Gallons per Minute)
GUNTER MEMBER OF GASCONADE FORMATION			
1. Boys Town of Mo. St. James	Phelps Co.	300	42
2. Oak Meadow (Country Club)	Phelps Co.	550	100
POTOSI FORMATION			
1. Bourbon (No. 2)	Crawford Co.	501	73
2. Cuba (No. 2)	Crawford Co.	1005	233
3. Salvation Army (Blue Spring)	Crawford Co.	530	?
4. Pres. Ch.	Crawford Co.	500	56
5. Steelville (No. 2)	Crawford Co.	535	?
6. Steelville (2A)	Crawford Co.	660	287
7. U.S.C.C.C.F. 13 (#1)	Washington Co.	501	35
8. St. James (2A)	Phelps Co.	1100	360
9. Rolla (No. 1)	Phelps Co.	930	200
10. Rolla (No. 6)	Phelps Co.	1150	580
11. Rolla (No. 8)	Phelps Co.	1125	550
12. Rolla (No. 4)	Phelps Co.	1175	300
13. Rolla (No. 7)	Phelps Co.	1215	585
14. Rolla (No. 5)	Phelps Co.	1078	540
15. Rolla (Mo.School of Mines)(2B)	Phelps Co.	1151	328
16. Owensville (No. 1)	Gasconade Co.	900	200
17. Owensville (No. 2)	Gasconade Co.	962	79
18. Owensville (No. 3)	Gasconade Co.	1000	?
19. Salem (No. 1)	Dent Co.	710	93?
20. Indian Trail St. Park (No. 2)	Dent Co.	455	25
21. Union	Franklin Co.	1000	349
22. St. Clair (No. 4)	Franklin Co.	838	36
23. St. Clair (No. 3A)	Franklin Co.	800	80
24. Meramec St. Park (No. 1)	Franklin Co.	605	25
25. Hillsboro (No. 2)	Jefferson Co.	1310	100
ROUBIDOUX FORMATION			
1. Gray Summit (School)	Franklin Co.	590	25
2. U. S. Government (Nike Base)	Franklin Co.	680	52

Exhibit No. 4

Well Data, cont'd

Meramec River Basin

Formation and Well	County	Total Depth Feet	Production (Gallons per Minute)
GASCONADE FORMATION			
1. Rosebud (No. 1)	Gasconade Co.	508	35
2. Eureka	St. Louis Co.	800	135
3. Pacific (2)	Franklin Co.	765	241
4. Pacific (No. 1)	Franklin Co.	650	150
5. Cedar Hill (No. 1)	Jefferson Co.	650	30
EMINENCE FORMATION			
1. Cuba (No. 1)	Crawford Co.	602	125
2. Bible Pres. Ch. (boy & girls Camp)	Crawford Co.	375	12
3. St. James (No. 1)	Phelps Co.	700	75
4. Vichy Airport (No. 1)	Maries Co.	850	103
5. Vichy Airport (No. 2)	Maries Co.	950	225
6. Rosebud (No. 2)	Gasconade Co.	700	96
7. Cedar Hill (No. 2)	Jefferson Co.	902	50
8. Hillsboro (No. 1)	Jefferson Co.	931	65
BONNE TERRE FORMATION			
1. Ironton (No. 6)	Iron Co.	300	36
2. Ironton (No. 4)	Iron Co.	424	46
3. Ironton (No. 1)	Iron Co.	293	70
4. Ironton (No. 2)	Iron Co.	467	18

Exhibit No. 5

Chemical Analysis of Public Water Supplies
Meramec River Basin
(Results in mg/l)

City	Treated or Raw	Total Dissolved Solids	Chlorides (Cl^-)	Sulfates ($SO_4^=$)	Hardness (as $CaCO_3$)	Iron (Fe)	Source
Franklin County							
Pacific	treated	382	6.4	12.8	312	0.3	Wells
Union	treated	221	7.3	41.2	140	0.02	Bourbeuse R.
St. Clair	raw	222	5.0	10.9	180	0.06	Aux. - Well
Sullivan	raw	192	4.1	7.6	162	0.01	Wells
Gerald	raw	380	4.5	10.9	316	0.14	Wells
Gasconade County							
Owensville	treated	305	5.5	18.3	256	0.14	Wells
Maries County							
Belle	raw	287	3.2	32.5	188	0.2	Wells
Phelps County							
St. James	raw	549	7.7	141.2	410	0.03	Wells
Rolla	raw	356	5.9	32.9	282	0.1	Wells
Dent County							
Salem	raw	263	5.9	0.8	212	0.4	Wells

Exhibit No. 5

Exhibit No. 5
(Page 2)

Chemical Analysis of Public Water Supplies

Meramec River Basin
(Results in mg/l)

City	Treated or Raw	Total Dissolved Solids	Chlorides (Cl^-)	Sulfates ($SO_4^=$)	Hardness (as $CaCO_3$)	Iron (Fe)	Source
Crawford County							
Steelville	raw	243	5.5	2.3	202	0.02	Wells
Cuba	raw	272	3.6	8.0	226	0.03	Wells
Bourbon	raw	204	5.0	2.1	172	0.02	Wells
Washington County							
Potosi	raw	320	6.4	22.0	238	0.14	Wells
Iron County							
Viburnum	treated	245	7.3	19.1	180	0.09	Well
St. Francois County							
Bismarck	raw	481	13.2	95.3	358	0.1	Wells
Leadwood	treated	427	11.4	63.0	296	0.01	Mine water
Elvins	treated	635	20.9	205.1	446	0.2	Mine water
Esther	treated	635	20.9	205.1	446	0.2	Mine water
Rivermines	treated	635	20.9	205.1	446	0.2	Mine water
Deslodge	treated	635	20.9	205.1	446	0.2	Mine water
Flat River	treated	635	20.9	205.1	446	0.2	Mine water
Bonne Terre	treated	-	-	-	-	-	Well

Exhibit No. 5 (Pg.2)

Exhibit No. 5
(Page 3)

Chemical Analysis of Public Water Supplies

Meramec River-Basin
(Results in mg/l)

City	Treated or Raw	Total Dissolved Solids	Chlorides (Cl^-)	Sulfates ($SO_4^=$)	Hardness (as $CaCO_3$)	Iron (Fe)	Source
Jefferson County and St. Louis County							
Hillsboro	raw	357	3.6	25.3	294	0.03	Wells
Valley Park	treated	315	29.1	65.2	198	0.04	Wells
Manchester		---	12.0	21.0	73	0.00	St. Louis County Water Company
Des Peres		---	12.0	21.0	73	0.00	St. Louis County Water Company
Kirkwood	treated	329	62.2	65.4	126	0.01	Rainey Well-Aux. Meramec River, St. Louis County Water Company
Fenton	treated	---	12.0	21.0	73	0.00	St. Louis County Water Company
Balwin	treated	---	12.0	21.0	73	0.00	St. Louis County Water Company
Eureka	raw	409	24.1	24.7	326	0.03	Well

Exhibit No. 5 (Pg.3)

Exhibit No. 6

Chemical Quality of Treated and Untreated Water *
(Milligrams Per Liter except Color, pH, and Conductance)

Meramec River Bottoms

	Untreated	Treated
Silica (SiO_2)	11	9.2
Iron (Fe)	.03	.02
Manganese (Mn)	.00	.00
Calcium (Ca)	65	21
Magnesium (Mg)	26	18
Sodium (Na)	21	20
Potassium (K)	1.8	1.0
Carbonate (CO_3)	0	18
Bicarbonate (BCO_3)	239	36
Sulfate (SO_4)	61	65
Chloride (Cl^-)	41	31
Fluoride (F)	.0	.1
Nitrate (NO_3)	1.3	1.0
Dissolved Solids	420	244
Hardness as $CaCO_3$		
Total	267	128
Noncarbonate	71	68
Color	2	2
pH	7.2	9.5
Specific Conductance	585	373
Turbidity	3	.2
Date of Collection	4/14/51	4/14/51

Treatment - Aeration, softening with quicklime, prechlorination, mechanical flocculation, sludge removal, settling, filtration, and postchlorination.

* Radial - Screened well, Kirkwood, Mo. from Geological Survey 216

Exhibit No. 7

Chemical Analysis of Mine Water*
(Results in mg/l except for pH)

Meramec River Basin

	Mine	
	Leadwood	Bonne Terre
CaO	98	120
MgO	52	107
Fe	Trace	0.5
Al_2O_3	Nil	Trace
Cl	23	19
SO_4	69	312
Total dissolved solids	486	922
Total alkalinity	236	290
pH	7.7	8.0

*Missouri Wood Study, MBASCO, 1962

Exhibit No. 8

Analysis of Spring Water
(Results in **Milligrams Per Liter)**

Meramec River Basin

Spring	River Mile*	Suspended Solids	Total Hardness As ($CaCO_3$)	Alkalinity As ($CaCO_3$)	Iron (Fe)	Calcium (Ca)	Sodium & Potassium (Na)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)
Krate	64-40-15	19	124	118	0.23	25.5	1.4	8.0	2.7	0.98
Meramec	165	1.4	149	148	0.87	30.2	3.3	2.7	2.4	1.73
Onandaga	130	Trace	221	216	0.44	47.6	2.2	4.3	2.7	1.39
Roaring	95	1.3	180	165	0.58	36.5	1.9	10.5	6.6	1.06

*Estimated

Exhibit No. 8

Exhibit No. 9

Public Water Supplies

Meramec River Basin

County Municipality	Pop. 1960	Pop. Served	Water Supply Source	Ownership	Treatment	Millions Gallons per Day (mgd) Capacity	 Consumption	Gallons per Capita per Day (gpcd)
Franklin								
Pacific	2,795	2,650	Ground	Municipal	F	0.576	0.170	64
Union	3,937	4,100	Ground & River	Municipal	C-F-D	1.32	0.55	134
St. Clair	2,711	2,690	Ground	Municipal	None	0.360	0.20	74
Sullivan	4,098	4,050	Ground	Municipal	None	1.73	0.375	93
Gerald	474	459	Ground	Municipal	None	0.21	0.035	77
Gasconade								
Owensville	2,379	2,550	Ground	Municipal	F	0.72	0.225	88
Maries								
Belle	1,016	1,000	Ground	Municipal	None	0.30	0.07	70
Phelps								
St. James	2,384	2,350	Ground	Municipal	None	1.44	0.15	64
Rolla	11,132	11,049	Ground	Municipal	D	2.88	0.8	72
Dent								
Salem	3,870	4,750	Ground	Municipal	D	0.27	0.54	114
Crawford								
Steelville	1,127	1,150	Ground	Municipal	None	0.43	0.06	52
Cuba	1,672	1,640	Ground	Municipal	None	0.50	0.175	107
Bourbon	779	750	Ground	Municipal	None	0.12	0.055	74
Washington								
Potosi	2,805	2,850	Ground	Municipal	D	0.72	0.18	63
Iron								
Viburnum	590	250	Ground	Private	H-F	0.648	0.180	-

Exhibit No. 9

Exhibit No. 9 (cont'd)

Public Water Supplies

Meramec River Basin

County Municipality	Pop. 1960	Pop. Served	Water Supply Source	Ownership	Treatment	Millions Gallons per Day (mgd) Capacity	Consumption	Gallons per Capita per Day (gpcd)
St. Francois								
Bismark	1,237	1,400	Ground	Municipal	None	0.35	0.15	107
Bonne Terre	3,219	4,025	Mine Water	Private	F-D	0.87	0.30	75
Leadwood)			Mine Water	Private	F-D	0.45		
Elvins)	Total Population		Mine Water	Private	F-D	Total	Total	
Esther)	of these six		Mine Water	Private	F-D	Capacity	Consumption	
Rivermines)	municipalities		Mine Water	Private	F-D	2.02	1.03	72
DesLodge)	14,307		Mine Water	Private	F-D			
Fiat River)			Mine Water	Private	F-D			
Jefferson & St. Louis								
Hillsboro	457	392	Ground	Municipal	None	0.210	0.035	90
Valley Park	3,452	3,363	Ground	Municipal	H-F-D	1.162		134
Fenton	1,046	1,046	Surface	Private	F-D	-	-	-
Eureka	1,134	1,050	Ground	Municipal	None	0.08	0.66	-
Kirkwood	29,421	29,500	Ground & River	Municipal	H-F-I-D	3.61	2.25	76

F - Filtration
C - Coagulation
D - Disinfection
H - Softening
I - Iron Removal

Exhibit No. 9 (Pg.2)

Exhibit No. 10

Summary of Alternative Cost Computations
for
Municipal and Industrial Water Supply in Lower Area
Meramec River Basin

Alternative	Year(s) Needed	Construction Cost	Annual O&M Cost	Capital Cost Discounted to 1970*	Annual Cost**
Transmitting all added needs from Missouri River	2020	$ 8,210,000		$1,655,000	
	2025-2045		$ 75,000	311,000	
	2045	14,090,000		1,790,000	
	2045-2070		205,000	234,000	
			Total ...	$4,010,000	$132,000
Single Purpose Reservoir Above Reach M-7	2025	14,000,000		2,825,000	
	2025-2070		100,000	442,000	
			Total ...	$3,267,000	$107,100
Transmission of Needs above Meramec River Flow from Missouri River	2025	9,140,000		1,845,000	
	2025-2045		60,000	265,000	
	2045	15,950,000		2,025,000	
	2045-2070		140,000	160,000	
			Total ...	$4,295,000	$140,500

*Construction costs are amortized for 25 years @4%, discounted for 25 years @ 3 1/8%, and the resulting capital cost discounted from the year of need to 1970 @ 3 1/8%. Operation and maintenance costs were discounted to 1970 @ 3 1/8%.

**Annual costs were amortized @ 3 1/8% over the 100 year project life.

Exhibit No. 11

Basic Data on Sources of Pollution*

Meramec River Basin

Location	River Miles Above Mouth	Population 1960	Population Sewered	P.E. (BOD) Design	P.E. (BOD) Raw	Nature of Wastes	Treatment Provided	Discharged P.E. (BOD)	Discharged Q
Meramec River	1,145								
Henke, Arnold, Ten Brook & Vic	2	Approx. 6000 Pop. in 12 sq. miles				Domestic	Private System		
Ten Brook, Maxville & Vic	3.5								
Mattesse Creek	4	Approx. 4500 Pop. in 12 Sq. Miles				Domestic	Private System		
Saline - Sugar Creek	10	Approx. 8000 Pop. in 17 Sq. Miles				Domestic	Private System		
Fenton	15	1,046	300		300	Domestic	Secondary	30	
Sunset Hills	15.5	3,525							
St. Louis Co. Water Co	16					Sludge	Holding Pond		
Kirkwood Water Plant	18					Sludge	None		
Chrysler Corp.	19.5					Ind. & Dom	Neutralization Lagoons		
Kirkwood #2 Plant	20-4-0.5	29,421	9,000	12,000	9000	Domestic	Secondary & Lagoon	900	
Manchester-Winchester	20-6	2,021		4,500		Domestic	Secondary		
Ramco Corp(Manchester)	20-65					Industrial	None		168,000 gpd
Valley Park	21	3,452	2,600	4,500	2600	Domestic	None	2,600	

Exhibit No. 11

Exhibit No. 11 (cont'd)

Basic Data on Sources of Pollution*

Meramec River Basin

Location	River Miles Above Mouth	Population 1960	Population Sewered	P. E. (BOD) Design	P. E. (BOD) Raw	Nature of Wastes	Treatment Provided	Discharged P.E. (BOD)	Discharged Q
Archer, D. Midland Co	21					Industrial	None till FY64		200 gpm
Absorbent Cotton Co	21					Industrial	None till FY64		8 dumps at 2,000 gal.
Meramec Hills Sub.			45		45	Domestic	Secondary	4.5	
Riverside Sub.			200		200	Domestic	Secondary	20	
Fawn Ridge Sub.			100		100	Domestic	Secondary	10	
Bellwin	22-2	5,710	2,655			Domestic	Secondary		
Eureka	32	1,134		970	970	Domestic	Secondary	120	
High Ridge Vic., Artie Creek	34	Approx. 2000 People in area				Domestic	Private System		
Big River	37-58-3								
Potosi	37-58-15.5-9	2,805	2,750	3,500	2750		Secondary & Lagoon	275	
Apex Mining Co.	37-68-8					Tiff, washing from Mill			1.3 mgd
Bonne Terre	37-79.5-2	2,900		3,800		Domestic		Under Construction	
Bonne Terre	37-85.5-1	320		400		Domestic		Under Construction	
Desloge	37-91	2,308				Domestic	Lagoon	Under Construction	

Exhibit No. 11 (cont'd)2

Exhibit No. 11 (cont'd)

Basic Data on Sources of Pollution*

Meramec River Basin

Location	River Miles Above Mouth	Population 1960	Population Sewered	P.E. (BOD) Design	P.E. (BOD) Raw	Nature of Wastes	Treatment Provided	Discharged P.E. (BOD)	Discharged Q
Esther	37-91-1.5-1	1,033					Private System		
Flat River	37-91-3	4,515	3,720	6,000	3720	Domestic	Primary	3,720(Plant Bypassed)	
Federals (River Mines, Mill #17, Mine #11, & Rim Mines)	37-91-3.5					Industrial	None		16.9 mgd pumped at night only
River Mines	37-91						Private System		
Elvins	37-91	1,818					Private System		
Leadwood	37-100	1,343					Private System		
Leadwood Mine & Mill	37-100-1								16.9 mgd pumped at night only
Irondale	37-110-2	335				Industrial	Private System		
Bismarck	37-110-7	1,237	995	1,200	995	Domestic	Secondary	250	
Meramec River									
Pacific	49	2,795	2,400	3,600	2400	Domestic	Lagoon	240	
Bourbeuse River	64								
Union	64-16	3,937	3,800	7,400	4400	Ind. & Dom.	Lagoon	440	

Exhibit No. 11 (cont'd)

Exhibit No. 11 (cont'd)

Basic Data on Sources of Pollution*

Meramec River Basin

Location	River Miles Above Mouth	Population 1960	Population Sewered	P.E. Design	(BOD) Raw	Nature of Wastes	Treatment Provided	Discharged P.E. (BOD)	Discharged Q
St. Clair	64-18-4	2,711	2,440	3,200	2440	Domestic	Secondary	244	
Sullivan #1	64-47-15-1	4,098	1,230	4,500	1230	Domestic	Lagoon	120	
Sullivan #2 & #3	64-47-17	4,098	2,450	4,500	2450	Domestic	Lagoon	245	
Ramco Corporation	64-47-19					Plating	None		0.16 mgd
Bourbon	64-79-13-1	779		636		Domestic	Lagoon	Under Construction	
Owensville	64-86-10-1	2,379	2,200	4,500	2200	Ind. & Dom.	Lagoon	220	
Bland	64-104-17-2	654	600	594	600	Domestic	Lagoon	60	
Belle	64-104-24-1.5	1,016	900	2,000	900	Domestic	Lagoon	90	
Cuba	64-109-14-6	1,672	1,000	1,440	1000	Ind & Dom	Lagoon	100	
Cuba	64-109-14-4-1	1,672	400		400	Domestic	Lagoon	50	
St. James	64-139-5	2,384	100	120	100	Domestic	Lagoon	10	
Meramec River									
Meramec Mining Co (Pea Ridge)	85-11-1-2			478	200	Iron Mine, Domestic	Drainage, Lagoon	20	
Indian Creek Shaft #25	85-13-7					Lead Mine Drainage			0.72 mgd Continuous
Viburnum Shaft #28 & Mill	131-1-27-3-2					Lead Mine Drainage			3.17 mgd Continuous

Exhibit No. 11 (cont'd)

Basic Data on Sources of Pollution*

Meramec River Basin

Location	River Miles Above Mouth	Population 1960	Population Sewered	P.E. (BOD) Design	P.E. (BOD) Raw	Nature of Wastes	Treatment Provided	Discharged P.E. (BOD)	Discharged Q
Viburnum	131-1-27-3-2	590	600	650	600	Domestic	Lagoon	60	
Viburnum Shaft #27	131-27-2					Lead Mine Drainage			3.17 mgd
Steelville	146-2	1,127	1,000	2,000	1000	Domestic	Secondary	100	
St. James	167-3-2	2,384	1,200	3,450	1200	Domestic	Secondary &Lagoon	120	
Rolla (East)	167-18-5-1	11,132	4,100	5,000	4400	Domestic &Industrial	Secondary	450	
Rolla (South)	167-18-5-1	11,132	6,700	12,000	7500	Domestic & Industrial	Secondary	750	
Salem	167-51-8	3,870	3,290	3,800	3290	Domestic	Secondary	330	

*From Missouri Water Pollution Board, October 1962

Exhibit No. 11 (cont'd)
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Exhibit No. 12
Summary of Single Purpose Reservoirs
For
Water Quality Control in Upper Area
Meramec River Basin

Reach	Draft on Storage Acre-Feet/Yr	Year of First Need	Construction Cost	Cost Discounted @ 3 1/8% to 1970	Annual Cost Amortized at 3 1/8%
B-1					
B-2	14,900	1990	$ 4,200,000	$ 2,270,000	
B-3		1990-2070	$ 42,000/yr*	665,000	
				$ 2,935,000	$ 96,200
M-1	14,700	1990	$ 5,220,000	$ 2,820,000	
M-2		1990-2070	$ 52,000/yr*	820,000	
				$ 3,640,000	$ 119,200
BG-1	26,600	1970	$ 5,940,000	$ 5,940,000	
		1970-2070	$ 59,500/yr*	$ 1,815,000	
				$ 7,755,000	$ 253,900
				Total in Upper Area -	$ 469,300

* Annual Operation and Maintenance Costs

Exhibit No. 13

Summary of Alternatives for Water Quality Control in Lower Area Meramec River Basin

Alternative	Year(s) Needed	Construction Cost	Annual Operation & Maintenance Cost	Capital Cost Discounted To 1970*	Annual Cost**
Single Purpose Reservoirs	1985	$14,000,000		$8,200,000	
	1985-2070		$140,000	2,620,000	
	2020	23,000,000		4,950,000	
	2020-2070		138,000	745,000	
	2045	41,000,000		4,080,000	
	2045-2070		160,000	272,000	
TOTAL				$20,867,000	$682,000
Combined Effluent Diversion and Flow Regulation	1985	7,450,000		$ 4,700,000	
	1985-2070		100,000	1,870,000	
	2020	11,000,000		2,360,000	
	2020-2070		310,000	1,670,000	
	2045	12,100,000		1,200,000	
	2045-2070		141,000	240,000	
TOTAL				$12,040,000	$394,000
	2020	27,000,000		$ 5,800,000	
	2020-2070		140,000	755,000	
				$ 6,555,000	$215,000
			TOTAL		$609,000
Combined Flow Regulation and Effluent Diversion	1985	14,000,000		$ 8,200,000	
	1985-2070		140,000	2,620,000	
	2020	23,000,000		4,950,000	
	2020-2070		138,000	745,000	
TOTAL				$16,515,000	$540,000
	2045	12,100,000		$ 1,200,000	
	2045-2070		300,000	510,000	
				$ 1,710,000	$ 55,000
TOTAL					$595,500

Exhibit No. 13 (Continued)

*Construction costs and Operation and Maintenance Costs were discounted to 1970 @ 3 1/8%.

**Annual costs were amortized @ 3 1/8% over the 100 year project life.